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Keeping the Dream Alive: Managing the Space Station Program, 1982–1986

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PREFACE

This monograph describes and analyzes the management of the formative years of the space station program (1982-1986) in the National Aeronautics and Space Administration (NASA). The time period covered begins with the successful initiative for program approval launched by Administrator James Beggs, through the initial program structure with the lead center at Houston, Texas, and culminates in the decision to bring program management to Reston, Virginia, a suburb of Washington, D.C.

By the term "management history" we mean a chronicle of the challenges faced by NASA managers and the processes used to meet those challenges. Since companion works dealing with the history of constituency building (authored by Howard McCurdy) and international participation (by John Logsdon) in the space station program are under way, we have placed greater emphasis on internal management issues related to the implementation of the various phases of the program from 1982 to 1986. Although we have tried to minimize overlap, some discussion of key external factors is necessary in order to place NASA's management challenges in their proper context.

We have invoked the metaphor of "an experiment," as provided by John Hodge, director of the Space Station Task Force, during our interviews with him, to describe NASA's efforts to arrive at a viable management structure for the space station program. We believe this term accurately captures the thinking of the key decision makers. The main players understood that the major program management decisions made in 1984 would be evaluated at the end of the detailed definition period in light of their experiences during that time. Only after such evaluation would the program move to the design and development phase.

We structure our narrative around four interrelated themes: the problem of bringing programmatic and institutional interests together and focusing them to forward the program; centralized versus decentralized control of the program, and how each option was affected by the requirements of technology and the program, the environment within NASA, and the budgetary constraints under which NASA was operating at the time; how the history of NASA and the individual centers affected the decisions that were made; and the pressure from those outside NASA (the external constituencies). The monograph is divided into four sections that are chronologically overlapping in some aspects: 1) the decision to build the space station, 2) the design of the management experiment, 3) the experiment comes to life, and 4) the decision reversal.

Part I presents the process by which NASA gained Presidential approval for the program. In chapter 1 a new Administrator (James Beggs) viewed the space station initiative as a means to revitalize NASA's technical and scientific competence. Only after revamping the reporting relationships between the field centers and headquarters did he openly work on the space station initiative. He wanted the space station to be an agency-wide program, have more than one prime contractor (unlike the shuttle where only one had been used), and be built "by the yard" (starting with an initial capability and adding onto that as funds became available). And during this early period he identified the key individuals who would spearhead the space station initiative. In chapter 2 we cover the four major organizational entities that were involved in this phase of the program: the Space Station Task Force, the Space Station Technology Steering Committee, the Fletcher Committee, and the Office of Space Science and Applications. Over time the task force became the focal point for delineating the details of the program. The unique

management of the task force, and its location at headquarters, promoted program integrity and minimized decentralizing forces within NASA. Frequent interaction among those in key leadership positions at all levels allowed the integration of both programmatic and institutional perspectives into the management and technological guidelines of the program. (Proponents of the institutional perspective focused on NASA as an ongoing organization, whereas program proponents viewed the organization as an instrument to accomplish major projects.) From a management perspective, the leadership style of Beggs and the management of the task force enabled NASA to win Presidential approval of the program.

Part II deals with how NASA arrived at the original program structure. The initial decisions and consideration took place at headquarters and within the Program Planning Working Group of the Space Station Task Force. As the prospects for approval improved, NASA included institutional elements at the field centers through meetings at Wallops and Langley, which are covered in chapter 4. These two meetings endorsed the lead center form of organization for managing Phase B of the program. Based on NASA's recent experience in the shuttle project, the lead center approach was the first attempt to find a balance between centralization and decentralization for the space station. In chapter 5 we begin the discussion of division of responsibilities among the centers, in the form of work packages. This process took much longer than had ever been anticipated. The ever-present need for sustained congressional support and institutional considerations made this decision quite difficult and the decision was finally made at headquarters.

In Part III we analyze the management of the program at headquarters and at the program management level. Included in this section is a discussion of the skunk works (chapter 7), formation of the headquarters program office (chapter 8), the formation of Level B (chapter 9), and the Phase B studies (chapter 10). During this period the resource and time requirements of the complex management structure became more apparent.

Part IV considers the evaluation of the lead center organization structure and the associated work package decisions. Chapter 11 deals with the turbulence caused by the departure of key space station program officers (including Administrator James Beggs, Deputy Administrator Hans Mark, Program Manager Neil Hutchinson, and the lead field center director Gerald Griffin) and the effect the Challenger accident had upon NASA as a whole and the space station in particular. Chapter 12 considers then Acting Administrator James Fletcher's decision in May 1986 to bring management of the space station program to headquarters, abandoning "the experiment" for a more traditional NASA form of management.

This narrative addresses an audience far broader than management professionals. We have made every effort to simplify our treatment of complex management issues so that the immense management challenges NASA faced can be appreciated by a greater number of people. We have analyzed documents from NASA's archives, although we have given great importance to oral sources of information. We have benefitted from many hours of interviews with NASA personnel, both at headquarters and at the field centers, in our reconstruction of the management story. The story is multifaceted. We have striven to represent the differing, sometimes divergent, perspectives. We have also tried to elucidate the perceptions of the players in the decision process. We owe an enormous debt of gratitude to those

NASA personnel who have given freely of their time; we hope we have represented their accounts accurately. Those who generously shared their insights and opinions are listed in appendix A.

We would especially like to acknowledge the following people for their contribution to the completion of this project. We thank Philip Culbertson, John Hodge, Robert Dotts, and Sylvia Fries for their comments on earlier drafts of the manuscript. We also appreciate the continuous encouragement given by James Begs, Robert Freitag, Lee Tilton, Neil Hutchinson, Jerry Craig, William Raney, Terence Finn, John Aaron, and Aaron Cohen. We are indebted to the archival support from Manfred "Dutch" von Ehrenfried, Lee Saegesser, Adam Gruen, and the NASA History Office in Washington, DC; Mike Wright at Marshall Space Flight Center; Donald Hess, Joey Pellarin, and Janet Kovacevich of the History Office at Johnson Space center; and Lee Tilton for his copious personal files on the space station program.

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KEEPING THE DREAM ALIVE:
MANAGING THE SPACE STATION PROGRAM, 1982-1986

PART I

THE NEXT LOGICAL STEP

CHAPTER 1

KEEPING THE DREAM ALIVE

I guess if I wrote my epitaph, I would write, 'He tried to keep the dream alive.'

--James Beggs
NASA Administrator, 1981-1985

The concept of a space station has been around for more than 100 years, but always as something that would happen in the future, never in the imaginer's lifetime. However, after the National Aeronautics and Space Administration (NASA) was established in 1958 and the agency's leadership contemplated a plan for its first decade, a space station was one of the top choices as a post-Mercury program. Indeed, in the first half of 1959, NASA's Research Steering Committee on Manned Space Flight had placed a space station ahead of a lunar expedition on its list of priorities. In 1961, however, President John F. Kennedy made a lunar landing the major NASA objective. Despite this change of priorities, the dream of the space station was kept alive throughout the 1960s through various engineering and design studies.[1] Under the coordination of the Advanced Missions Office of the Office of Manned Space Flight at NASA headquarters in Washington, these early in-house and contractor studies were managed by three NASA field centers, the Manned Spacecraft Center (Johnson Space Center) in Texas, the Marshall Space Flight Center in Alabama, and the Langley Research Center in Virginia.[2] Work on the shuttle dominated the 1970s, despite the launch of Skylab in 1973, which was a "quasi-space station" effort, and space station-related studies continued, primarily at Johnson and Marshall.[3]

NASA had tried several times over the years to win Presidential approval for the space station and had failed each time. With Kennedy's decision to go to the Moon, the chances of developing a space station in the 1960s vanished. Efforts to gain approval for station development from the Nixon Administration failed, and the Ford and Carter Administrations rejected funding requests for the space station as well. By the late 1970s it was clear that any substantial money for a space station would have to wait until the agency demonstrated success with the shuttle, but the shuttle was then experiencing technical difficulties as well as cost and schedule overruns.[4]

It was left to James M. Beggs, the agency's sixth administrator, to make the next attempt to win presidential approval for the space station program.

Administrator Beggs

James Montgomery Beggs, a Pennsylvanian by birth, was not a newcomer to government service, the space industry, or NASA. He had served in the Navy, been with NASA and the Department of Transportation (DOT), and had worked in the private sector before returning to NASA in 1981 as the new administrator.[5] Ronald Reagan nominated Beggs to that post soon after he himself took office.

Beggs had a number of assets that could serve NASA well. He was closely connected to the Republican political establishment, and he understood Washington political life, given his previous tenure with NASA and DOT. His time in private industry also gave him an extensive familiarity with the aerospace industry. Even though he had left NASA in 1969, he had kept himself abreast of the

agency's developments. Indeed, in 1977 he had chaired a panel of the National Academy of Public Administration that concluded that NASA was the operational home of the shuttle unless the economics of the shuttle changed drastically.[6]

Reagan also appointed Hans Mark to be Beggs' deputy administrator. Mark had served as Undersecretary of the U.S. Air Force during the Carter Administration and had known Beggs since the late 1960s.[7] He was widely believed to be affiliated with the Democratic Party and had excellent credentials as a scientist. He had previous experience with NASA (having served as center director at Ames from 1969 to 1977) and was well known in the Washington environment. Beggs and Mark would spearhead the attempt to win approval of the space station.

The Confirmation Hearings

Mark visited Beggs as soon as he was selected to be the deputy administrator. This meeting gave them the opportunity to establish the priorities for NASA that they would present at their confirmation hearings, and the space station was one priority they agreed on.[8]

Although Beggs was committed to gaining approval of the space station, he chose to downplay his commitment during the confirmation hearings because he did not think NASA had the broad support needed at that time to establish a new major manned space program. This support would have to be created from industry contractors and the political and scientific communities. It was not likely that a major program such as the space station would be approved without support from these groups,[9] and this may have been why Beggs chose to de-emphasize the space station initiative during the hearings.

As a NASA associate administrator under Administrator James Webb in 1968, Beggs had had the opportunity to observe a superb administrator in action in a public agency. During his tenure, Webb had emphasized three key themes: 1) the importance of flexibility and adaptability in the organization; 2) building external constituencies; and 3) shared decision-making at the top.[10] During his confirmation hearings, Beggs expressed several themes of his own management philosophy, and they sounded much like those of Webb. First, Beggs emphasized the need for fast organizational responsiveness. Second, he underscored the importance of external constituencies. Third, more by implication, he suggested the need for a collaborative relationship with his deputy.

Beggs also portrayed his internal management philosophy in concrete terms. He planned to operate NASA in a decentralized fashion, as he was used to doing in private industry, but also planned to have adequate controls to determine early on if anything was amiss.[11] He would stay personally involved in the organization so he would know what was going on at all times.[12] Beggs was emphatic about which organizational form worked best. "[T]he organization that works best is one that is well decentralized, where the guy who has to do the work has the resources and the responsibility and the authority to get the job done."[13] He also described his external role. In research and technology, the user was important, and he intended to work very closely with industry as well as the academic community, since this is where many new ideas originate.[14] He also felt that the astronauts were very important in gaining public support for the program.[15]

In addition to his management philosophy, Beggs brought a set of priorities to NASA. The shuttle program needed attention, and the space science program had to be revitalized. But beneath these priorities Beggs believed the manned space station was "the next logical step" for NASA. Many in NASA

supported him in this, of course, since the space station had long been a cherished dream.[16] Therefore, in his confirmation hearings, he committed himself to undertake a permanently manned space station.[17]

Mark endorsed the "hands-on type of management" Beggs advocated. However, Mark was also keenly interested in personnel matters. He was convinced that the key in any organization was to pick good people, and that the success of the organization was based on the success of that selection.[18] Mark also echoed space station themes remarkably similar to those of Beggs. "I fully concur with what Mr. Beggs has said. I think that is the natural next step, the establishment of a permanent presence in space."[19] Thus, the Beggs/Mark team pronounced space station as NASA's long-range goal.

Despite their agreement on the space station, neither Beggs nor Mark would commit to a specific timetable for the program. In fact, both were very careful *not* to do so. Beggs was aware of the work that needed to be done before NASA would be ready to place a space station initiative before the President for approval, and a specific timetable could interfere with getting the job done properly.

Beggs' First Priorities for NASA

When he took office, Beggs did not push for immediate approval of the space station program. NASA's credibility was on the line because the delays and overruns of the shuttle had fostered a public perception of careless management practices within NASA.[20] Although previous NASA executives had begun to turn the shuttle project around,[21] NASA had not yet conveyed to the public their success. As a result, Beggs' first priority once he took the reins was to make the shuttle operational. At the same time, he gave top priority to revitalizing NASA's space science and applications programs. Over time, payloads were scheduled for the shuttle and other NASA programs, and Beggs repeatedly endorsed the long range planetary goals of NASA's Solar System Exploration Committee.[22]

As Beggs had promised in the confirmation hearings, he set out to revitalize NASA's scientific and technical talent. He felt that the agency had "grown old," hanging onto older employees who had retired and then had been rehired. He felt this destroyed the morale within the agency and insisted that NASA hire younger people.[23] By doing so, Beggs wanted to create an attitude in the field centers that encouraged risk taking. He wanted leadership at the center director's level that was willing to motivate and get things done. He didn't feel this attitude existed when he took over as administrator.[24]

Beggs and Mark also undertook a major reorganization at headquarters. They consolidated the Office of Space Sciences and the Office of Space Applications into the Office of Space Science and Applications. Historically, space sciences and space applications had been a single office and had been split in 1978 when Robert Frosch became administrator. Mark felt the division was awkward because the same technologies and people were involved in the two offices, so this part of the reorganization was done simply to correct what Mark felt had been a mistake in the first place.[25] As a part of this top level reorganization the Office of Space Operations was folded into the Office of Space Transportation Systems and renamed the Office of Space Flight. Since the Office of Space Operations had just come into existence, this was regarded as renaming rather than consolidation.[26]

The third aspect of the reorganization pertained to the reporting relationships between the field centers and headquarters. Although NASA had been through several realignments of the headquarters-field center relationships in the 1970s, Beggs chose to reorganize the agency once again. Under Frosch (1977-1981) the program offices and field centers reported directly to the administrator. After Beggs' reorganization the centers once again reported to the program offices for which they performed the bulk

of their work, as had been the case during the Apollo Project. This meant that the Jet Propulsion Laboratory and Goddard Space Flight Center reported to the Office of Space Science and Applications; Ames Research Center, Langley Research Center, and Lewis Research Center to the Office of Aeronautics and Space Technology; and Lyndon B. Johnson Space Center, John F. Kennedy Space Center, George C. Marshall Space Flight Center, and the National Space Technology Laboratories to the Office of Space Flight. In addition, two centers, Dryden Flight Research Center and Wallops Flight Center, were renamed facilities reporting to, and managed by, the Ames Research Center and Goddard Space Flight Center respectively. This reorganization reduced the span of control of the administrator since the centers reported to associate administrators, rather than to the administrator's office.[27]

At this same time Beggs began to take the first steps toward gaining the space station program's approval. To the outside world the space station was kept in low profile. Internally, however, Beggs began organizing for its approval. The space station was not just another program, but one that might have a major impact on NASA.[28] Therefore, the new space station initiative had to be carefully thought out and presented.

Beggs had committed to neither the shape nor form of the station during his confirmation hearings. He seemed to hold two basic beliefs, however, but beyond these beliefs there was no distinct commitment to program specifics. First, he believed the space station initiative should enlist the cooperation of international partners.[29] Second, this initiative was to be user-sensitive.

The station's management issues were not trivial, however. The agency was called upon to marshall its energies to win approval of a program which both the administrator and the deputy administrator had left undefined, perhaps deliberately. A process had to be managed, a process that yielded answers to crucial questions such as: What kinds of information needed to be generated to give the space station a concrete form? What principles should guide and what policies should shape the program? How should one organize to win approval? How should the institutional elements of other programs be linked into the effort?

All these questions had to be answered without a specific budget allocation to support the program because the program did not exist at this point. It was an extremely uncertain but challenging managerial task because the new initiative might fail, and all efforts might be for naught. Yet NASA's top executives made the decisions and set policies that established the course of the program. There was the opportunity to be involved creatively, to contribute, and to be part of the realization of a long-held dream of the agency. This was a time for the adventurous, not for those accustomed to routine life.

In the past, NASA headquarters had directed efforts to win approval of major programs. Over time, the roles of the field centers and headquarters had evolved to a point where the engineering and scientific expertise lay with the centers and the policy and liaison expertise was at Washington. Headquarters won program approval and field centers implemented. Following this tradition, Beggs chose to direct the effort to win the space station from headquarters.[30] There were several program offices that could have logically housed the space station efforts. The Office of Space Flight was perhaps ideally suited—given its oversight of the shuttle project. Beggs decided, however, that the space station effort was to be managed separately from these offices.

There are several plausible reasons for this decision. First, since Beggs had given priority to improving the shuttle's management practices and building the space sciences programs, he may not have wanted the respective program offices to take on a major effort such as the station. Second, Beggs may have had a vision of a manned space station as a multipurpose entity serving scientific and

industrial communities. Third, Beggs may have wanted many constituencies to support the effort; locating it within the Office of Manned Space Flight or the Office of Space Science could have alienated personnel in other program offices.

Although there was nothing formal at this stage, this decision resulted in what was later to become the Office of Space Station. Beggs picked Philip E. Culbertson to act as the primary link between the administrator's office and NASA's new space station initiative.[31] Within the headquarters organization, Culbertson thus became the focus for organizing and managing the space station initiative. He was also the key tie to Beggs and Mark.

Culbertson assessed the circumstances in which he had to organize the space station initiative. First, as the future of the agency itself was believed to reside with the space station, the extreme importance of this initiative was not lost on the headquarters program offices. Second, specific technologies for the station would need to be developed at other program offices. Since there was little money to start with, the space station had to rely on other programs for technology development, and other program offices had to take into account the station's technological needs when preparing their own advanced development programs. Third, Culbertson had to depend on other offices for budgets and personnel. To some extent, the institutional administrators themselves were infected with enthusiasm for the station, and the backing of Beggs and Mark helped create a spirit of cooperation among the programs. Culbertson, nonetheless, was sensitive to the need for maintaining his working relationship with other associate administrators.[32] Fourth, he had to accomplish all of this without impairing program goals and integrity. Thus, a new program had to take shape amid the push and pull of other programs, and at the same time had to rely on others' personnel and budgets.

Beggs and Mark launched the space station initiative by forming the Space Station Technology Steering Committee (SSTSC) to assess technologies already available within the agency. Established in 1981, the SSTSC was composed of NASA personnel only. It was headed by Walter Olstead, and operated under the Office of Aeronautics and Space Technology (OAST). The Fletcher Committee was established simultaneously, under the chairmanship of James C. Fletcher, to consider related issues. The Fletcher Committee was composed of people outside the NASA organization.

The first issue to be looked at was the station's technological feasibility. An agency-wide assessment of the technologies already available and currently developed within NASA (and the aerospace community) was essential. The job of the SSTSC was to find out if any new technology was needed for the space station program.[33] If the SSTSC could ascertain any gaps in the technology base and see that they were filled, the appropriate technologies would be available when the program was approved.[34]

Although the SSTSC operated until after the Space Station Task Force was formed, early deliberations indicated that different concepts of the station could not be reconciled on technological grounds. Perhaps more important to the top administrators, the SSTSC concluded that the technology issue in the space station program was relatively less complex than the technological problems NASA had confronted with Apollo and the shuttle.[35]

While the SSTSC was exploring technology needs, the Fletcher Committee was looking at program alternatives. There were differing programmatic recommendations from Johnson Space Center and from

Marshall Space Flight Center. The Fletcher Committee was a means to sort out those alternatives.[36] The Fletcher Committee was not affected by the parochial interests of the individual centers and could, therefore, be relied on to be objective or neutral in sorting out the various alternatives offered.

Initial Strategy

Beggs' primary interest as it evolved over the first few months of the task force was institutional. He wanted to revitalize the scientific and technological capabilities of NASA. He believed the space station program, once approved, was the way to accomplish that goal. Although Beggs and Mark were both committed to the program, they initially had differing priorities. One major difference concerned the involvement of the Department of Defense (DOD). Mark wanted DOD to be involved in the program. Beggs felt it should be a civilian station and that if DOD wanted a space station, they should take NASA's technology and build one of their own. He also felt that DOD involvement would make it more difficult to have international participation in the program because of security restrictions.[37] The differences between the two over the question were settled, however, when DOD proved uninterested in NASA's civilian initiative.

The first guiding principle of Beggs' space station initiative that emerged from the deliberations of the SSTSC and the Fletcher Committee was that NASA would undertake a relatively major space station program rather than a smaller one. He felt that the smaller station would not hold much credibility and would be rejected by the Office of Management and Budget before it ever got started. He explained:

> [The small station] was a strategy that we considered, but I didn't think it would be fair to the agency if we were to dump this, give them this wet leafy bag when we left, because I knew I would be gone before the thing really got under the peak—except I didn't think I was going to be gone as soon as I did—and I felt we should be more responsible, that's why we took the $8 billion. The $8 billion was not a slimmed down estimate, it was an unembellished number that the guys in the Task Force thought was reasonable.[38]

Although NASA would start with an $8 billion station, Beggs felt the agency should be able to add more money and technology over the years; NASA would build a station "by the yard." ("By the yard" meant that the station would meet the basic requirements of a permanently manned presence in space and could be expanded depending on the amount of money NASA received in the future.)

Beggs' second principle was to involve the entire agency. He felt that agency-wide involvement would motivate the agency by getting more than one center involved. He was also aware that involving several centers would make it more difficult to manage, but Apollo had been a multi-center program, and he felt the agency was up to the challenge. If they stuck to the fundamentals, Beggs felt that NASA could manage very complex and widely spread programs.[39]

He chose not to commit NASA to a single prime contractor, however, as had been done with the shuttle, and a third principle was formulated. "I guess my feeling was that this was different than anything we've done before. The station is not an airplane, or even a space shuttle."[40] This gave him the option of changing some aspects of the program, rather than following the example of other programs (such as Apollo or the shuttle).

Finally, he felt it was advisable to have international participation. The support of the international community was needed from a financial point of view, and their involvement would be beneficial for two reasons.[41] First, of course, it would spread the cost, and help leverage the $8 billion so more could be

done. Second, Beggs believed that when the international partners enter a program, they always commit to the full program. Involving internationals in the program would add stability because other countries generally make longer commitments than the U.S. budgetary cycle allows and because Congress is normally reluctant to cut off programs that have international participation.[42] Based on these beliefs Beggs launched preliminary negotiations with international partners: the European Space Agency (ESA), Canada, and Japan.

NASA, therefore, planned an agency-wide program without a single prime contractor, a program to be built by the yard over the years. The contours of the initial strategy were clearly laid out by Beggs and Mark. It was also clear that the space station initiative needed an organization to provide focus and direction for its planning activities.

Field Center Leadership

By 1981 the centers had become aware of the new initiative. A Space Station Projects Office was created at Johnson following a visit by General James Abrahamson. Christopher Kraft, the center director at Johnson, chose Robert Piland to be the project officer.[43] At Marshall, the new initiative echoed in the Advanced Programs Office, with Luther Powell initiating the space station effort at that center. The other centers were not yet involved.

Several of the field centers had established leadership with William Lucas at Marshall, Donald Hearth at Langley, and Richard Smith at Kennedy. At other centers Beggs made key appointments. Andrew Stofan was selected to be center director at Lewis.[44] He was from Lewis originally and had a good reputation as an administrator. Noel Hinners was chosen to head Goddard. Hinners' youth was to his advantage,[45] and Beggs felt he was creative, good with people, and a top motivator.[46] Lew Allen was chosen to lead the Jet Propulsion Laboratory,[47] and Gerald Griffin was selected to replace Chris Kraft at Johnson. Culbertson recommended Griffin very highly,[48] and Beggs felt Griffin was a good administrator and a good people manager.[49]

Under Griffin's direction, Johnson underwent a major top-level reorganization. Kraft had functional and project heads reporting directly to him, and Griffin felt that this span of control was too broad. He reorganized the functional and project heads to be members of his executive committee and readied himself to undertake a major new program for Johnson Space Center: the space station, once it was approved.[50]

In sum, this very early phase of the space station program was a period of genesis. Formal organization did not exist and much of the activity was informal and exploratory. The policies and principles that would guide the space station effort were beginning to create the structure that would be needed once the space station initiative received Presidential approval. The new center directors were selected by Beggs and Mark in consultation with Culbertson. They deliberately built a strong top management team, people aligned with the space station program, and particularly with Beggs' new style of leadership.

From a management perspective, this was an important era. The space station was to be an agency-wide initiative which, once approved, would stand as a unique program in spite of its interdependencies with other programs. One key player, Phil Culbertson, had been chosen. A key information-gathering mechanism—the SSTSC—was in place. Efforts to forge institutional arrangements between the space

station and other program offices within NASA had already started, and preliminary negotiations with potential international partners had begun.

Institutionally, the Beggs/Mark era was under way. Although NASA, on the whole, exhibited organizational continuity, four field centers had undergone leadership changes. At headquarters a new organization had been established.

CHAPTER 2

MANAGING THE CONSTITUENCIES

Recognizing the budget constraints on NASA,[1] the agency's top executives decided to gather both internal and external support for the program. As a first step toward building an external constituency, James Beggs hired John Hodge,[2] a former NASA employee, from the Department of Transportation. Hodge had heard that Beggs had returned to NASA, and he had written asking for a job. Beggs suggested to Phil Culbertson that Hodge be interviewed to work on the space station program. Culbertson interviewed Hodge and decided to bring him on board.

Beggs had already chosen Culbertson for a leadership role in the program, but Culbertson had other responsibilities as well. He was in charge of the task force that was created to provide a commercial policy for NASA and was also the number three man in the administrator's office.[3] Culbertson needed help and Hodge was the answer. According to Beggs, this was a perfect match of two individuals with differing areas of expertise: the institutional acumen of Culbertson and the creativity of Hodge. Culbertson knew NASA and understood the people and the organization.[4] Hodge, on the other hand, seemed to think differently and was very innovative. Beggs commented, "If you can't get one guy who is both a good people manager and creative, you get two, one creative and one a good people manager."[5]

When Hodge returned to NASA he joined Terence Finn, who at 39 had a doctoral degree in political science from Georgetown University, and, as a former NASA head of congressional liaison, had a tremendous knowledge of what made Congress work. Daniel Herman, who in eleven years at NASA headquarters had helped develop major planetary missions while also maintaining close ties with the scientific community, also joined the group.[6] Hodge was not familiar with either Finn or Herman when he was recruited, having spent twelve years with the Department of Transportation. He had no involvement in their appointments, but he came to admire them: they were the "mavericks" that he needed for the space station initiative.[7]

The three were joined by Robert Freitag, probably the most knowledgeable person on space station issues and a well-known figure among the field centers.[8] Hodge and Freitag knew each other well from the Apollo days. Hodge, Freitag, Finn, and Herman deliberated issues such as policies, cost, international partners, DOD participation, and the impact each issue could have upon the program.[9] Although Beggs was not involved in these discussions, Hans Mark was, often arguing against positions he didn't like.[10]

This group, which eventually formed the task force, also held informal meetings at their homes. Hodge recalled that Culbertson was at one meeting. Mark attended another one.[11] Beggs, of course, did not attend. He let the task force work, refine its options, and consult him.

> I deliberately stayed away from that [the informal meetings], partly because I didn't want them to try to tailor whatever they were doing to what they thought I wanted. My style is to try to give a group a challenge, an objective, and then to let them go get it. People are the same the world over. If they think they have discerned what it is that you're after, they'll give it to you. If you want to enhance creativity and innovation you've got to be very careful that they don't get the impression that you want it to go in a certain way.[12]

Of course, Hodge kept Beggs and Culbertson informed of the task force's progress.[13]

As they bounced their ideas around, however, it became clear that Beggs and Mark needed a larger group to help promote the station. At the end of March 1982, Freitag made a formal presentation to Culbertson in which he recommended, with the concurrence of the other members of the team, that NASA create a Space Station Task Force.[14]

The Space Station Task Force

On May 20, 1982, Beggs announced the establishment of the Space Station Task Force, to be directed by Hodge and reporting to Culbertson. Hodge chose Freitag as his deputy, and they were joined by Finn and Herman.[15] Beggs authorized the task force to develop the programmatic aspects of the space station. The task force would run for 12 to 18 months, through the awarding of the Phase B contracts. The task force's responsibilities would include the development of the space station program plan and the organization of a constituency.

Hodge saw himself as a catalyst for change within NASA. The task force could be a forum in which new ideas could be tested.

> ... [T]he goal of the Space Station Task Force was not simply to get a space station sold. Jim Beggs was using it to test thoughts and ideas about what NASA was going to be when it grew up. So you found yourself making decisions that were not 100 percent consistent with the space station itself, but in relationship to what NASA might become as a result of that.[16]

Hodge was familiar with task forces from his work as part of the Apollo project. He worried, of course, that bureaucratic pressures might defuse the purpose of the Space Station Task Force.[17] Hodge, unlike Beggs, had acquired a programmatic perspective. He felt that NASA should exist because it has the programs, not exist for its own sake. The key to the system should be the program manager and the institution should provide the support function.[18] He was aware, however, that some might argue that the institution should be the operational focal point, and that when the program was gone, the institution would still be there.[19]

Over the next several months, Hodge assessed the factors, which he called "boundary conditions," that affected the task force's initiatives. One of these was Beggs' management style, which Hodge characterized as "permissive." Beggs did not get involved in delineating the alternatives, and thus Hodge was free to pursue the task force's objectives.[20]

This leadership style, called "crescive" by management scholars, emphasizes the development of what the organization should look like and encourages individual creativity and risk-taking in the process.[21] The leader can then approve alternatives conforming to the mission that he has articulated for the organization. This style of leadership encourages entrepreneurship within large organizations, often referred to in management literature as "intrapreneurship."

The second boundary condition pertained to the reporting structure of the task force. Hodge felt that the task force could both report to the administrator's office through Culbertson, and simultaneously to another NASA program office such as the Office of Space Flight.[22] Mark, in Hodge's recollection, did not approve. "With his sort of Teutonic background, the concept of having more than one master was just anathema to him."[23] In the end the task force reported to Culbertson at the administrator's office.

The associate administrators needed to be involved in the task force, so the Space Station Steering Committee was established. This move was enthusiastically endorsed by the task force members.[24] Herman remembered this idea as Finn's contribution,[25] although Culbertson also claimed the idea as

his own.[26] According to Hodge, the steering committee should keep the institutional elements in NASA informed of the task force's activities. Since Hodge did not believe in secrets, the associate administrators were briefed once a month. "It was a sort of an advise and consent kind of process—as open a communication process as possible."[27]

Howard McCurdy has told the story of how the Space Station Task Force helped build the constituency for the space station program.[28] NASA had a historical legacy of task forces and the 1980 version was a continuation of that legacy. The Space Station Task Force was patterned loosely after the Space Task Group of the 1958-62 period which had formulated the manned space program, and was also influenced by a 1970s version of the task force.[29]

As the Space Station Task Force began work in earnest, several other boundary conditions that affected the task force became evident. One pertained to technological concerns. The task force had to incorporate the recommendations of the Space Station Technology Steering Committee (SSTC), as new technology development was essential to realizing the station's growth potential.[30]

Another boundary condition concerned the architecture of the space station itself. NASA had a long list of options advocated by the different field centers: examples included the manned orbital research laboratory, Saturn IV-B workshop, the manned orbital systems concept, the space construction base, the space and application manned space platform, the space operations center, and Spacelab.[31] In addition, the Fletcher Committee had completed its work, recommending a $2 billion space station, an amount far below what Beggs had expected.[32]

These boundary conditions set the stage for the Space Station Task Force. In addition, however, the Space Station Task Force would have to work in an environment where the field centers advocated different options, and a consensus did not exist within NASA as to the kind of space station that was to be built. This was a problem, since if one field center felt left out, this could jeopardize the prospects of getting the program approved. The need for external constituencies and internal consensus was mutually reinforcing. Accordingly, the task force began to outline some of the guidelines of the space station program.

Two of these guidelines are especially significant: NASA-wide involvement and an emphasis on missions. Institutional and political considerations led the task force to adopt the stance that the space station program would involve the entire agency. To build as wide a constituency as possible, the centers were involved in both the agency-wide initiative and the planning process. Programmatically, of course, Beggs had advocated the space station as the next logical step for the whole agency; these guidelines, therefore, were consistent with Beggs' intentions as well. Bringing the centers into the process had ramifications, however, which the members had deliberated earlier. NASA's field centers had evolved over time, both culturally and organizationally, into entities very different from each other. There were development centers, Marshall and Johnson; technology centers, Langley, Ames, and Lewis; and a major science center, Goddard. Each had a different background. The development centers were adept at cutting metal and working with the manned programs. The technology centers worked with advanced technology development; they were interested in research rather than development work (conceptualization rather than construction). And the science center, Goddard, had a history of responsiveness to the major user constituency, the space scientists.[33] NASA's planning activity also implied that both manned and unmanned elements of the programs would have to be brought together in the space station. Because of the diversity among the centers, the space station program served as a melting pot of the cultures and backgrounds of those centers.

The second important guideline was to emphasize missions, not a specific space station design. Based on the earlier findings of the SSTSC, it was clear that an internal consensus with respect to the nature of the space station did not exist. Absence of such a consensus could have a devastating effect on the program. Each of the centers could implicitly refrain from participating in the advocacy process that was essential in gaining the station's approval. Marshall had always wanted to build the space station incrementally, whereas Johnson wanted a space station to be built all at once. The controversy between the two was averted by the task force's focus on missions to drive the space station; engineering considerations would come later after the missions had been understood. This controversy was one of the reasons why Hodge would not let a picture of the space station be drawn until considerably later in the program. Hodge also knew from his experience with the shuttle that any premature design of the space station could be criticized by NASA outsiders.[34]

Eight mission analysis studies, funded by the Office of Space Flight, kicked off the task force activities. Two objectives lay behind these studies: first, to establish the needs of the station (i.e., user requirements), and second, to build a constituency.[35] At Mark's urging, meetings were also held with DOD officials to determine whether the Pentagon would be involved in the program.[36]

Staffing

Hodge and Freitag quickly recruited personnel for the task force once it was decided that there would be one. Freitag estimated that between 25 and 125 people a year would be needed to serve on the task force.[37] They would be drawn from headquarters and field centers. Hodge visited all the centers, looking for a lead person in each institution.[38] In addition to Finn and Herman, two others had joined Hodge's group. One was Francis T. (Frank) Hoban[39] from headquarters and the other was Brian Prichard from Langley. Walter Olstead had suggested that Hoban get involved in the space station program. Hoban talked to Hodge, who suggested he join the task force, and he did.[40] Prichard managed the contractors for the mission analysis studies.

The group of five (Hodge, Finn, Herman, Hoban, and Prichard), of course, was too small a group to handle a job the size of the one facing the Space Station Task Force. So additional recruiting from headquarters and the field centers took place. The task force recruitment employed unconventional means. Hodge explained:

> The way we collected the task force was not by advertising, but by people popping in [to Hodge's office] and sitting and saying, what the hell is going on here? And I'd say, well, I don't know if it's real. I'd always try to persuade people not to join, because I'd say the chance of selling the space station are less than 50 percent and if you've come to join us you're joining a bunch of mavericks. The organization you leave is going to ask why you left, and trying to get back if we fail will be difficult. So I always stressed the negative side. And I guess a third of the people said, I don't care, I'm still coming to work with you if I can.[41]

This process allowed many field centers to be involved. Detailees came on 30, 60, or 90 day tours, some even longer. They came from all the centers and were loyal to the project. This was assisted by Hodge's philosophy of little formal management. One day a person would be supporting another individual and the next day, on a different problem, the positions would be reversed. Even contractors were involved.[42] As Freitag recalled, "They didn't care if they were working for Marshall, Houston, headquarters, a contractor, or who. [And] we were able to get a lot of excellent people."[43]

Agency reorganization of the Office of Manned Space Flight and the Office of Operations had created a surplus staff which enabled the task force to recruit at headquarters.[44] No associate admin-

istrators interfered during this selection process because the task force was tied into the administrator's office, and no one wanted to "make waves." There also seemed to be a very good chance that the program would ultimately be approved, so everyone kept their hands off.[45]

There were, however, some glitches along the way. The manned space flight centers were slow to respond. Hodge and Bill Lucas of Marshall had worked together on early space station studies in the late 1960s.[46] Lucas and Hodge had corresponding jobs at Marshall and Johnson, and although they held differing points of view, they respected each other. Because of their previous relationship and mutual respect Hodge persuaded Lucas to send detailees to headquarters. As Hodge saw it, "We agreed that we had to amalgamate the centers. ... So I got a lot of people from Marshall."[47] Johnson was slower to respond, perhaps because of resentment of headquarters' control of the task force. So, in the earliest days, very few Johnson people were involved with the task force. This changed later, of course, when Houston learned that Marshall personnel outnumbered Johnson personnel on the task force, and Johnson was "losing out."[48]

The people that the task force attracted were, in Hodge's words, "mavericks." They stuck their necks out, dedicated themselves to the program, and cast aside institutional identities, at least for a time. Most loved working in an unstructured environment, and those that did not went home.[49] At any rate, the majority became closely identified with the program. According to Freitag, once everyone joined the task force, they worked shoulder to shoulder and quickly became loyal to the project organization.[50]

The task force eventually included detailees from all the field centers, including the Jet Propulsion Laboratory. Hence, a space station program, if approved, would allow every field center to contribute its unique expertise and capabilities. Hoban wrote:

> The mixture of headquarters and field center employees was quite necessary: the headquarters employees were skilled in dealing with the bureaucracy and Congress, while the field center employees had ideal expertise to conduct engineering studies and cost estimates. This mixture proved to be very synergistic.[51]

Although it had not been planned, the task force attracted many people who had been involved in at least one of the earlier space station studies, or had participated in the Space Station Technology Steering Committee. This too contributed to the agency-wide experience base.

Task Force Organization

The Space Station Task Force was organized into a number of working groups. Working groups were task oriented, and as new tasks emerged, new groups were formed.[52] Over time the task force had five major working groups: the Mission Requirements Working Group, the Systems Working Group, the Program Planning Working Group (PPWG), the Operations Working Group, and later on, the Concept Development Working Group (CDG). All of them reported to the Director of the Space Station Task Force, John Hodge. In addition, there was a Program Review Committee, chaired by Robert Freitag, consisting of representatives from headquarters and the centers. It monitored the progress of the working groups and served as a forum for bringing institutional concerns into the task force.[53]

Several conditions enabled the loosely structured task force to function well. First, the Space Station Task Force was generally considered to be temporary. It would end once the program was approved and the program plan was worked out. Second, the task force had a unifying mission; issues of how to allocate resources among programs and eight field centers were not important to the members in the early stages. Hence, parochial priorities of other programs or the centers were not prominent during this

period. Third, compared to the centers' ongoing programs, the Space Station Task Force was relatively small, enabling a common goal to develop. Fourth, since the program had not been approved, the task force's resources were relatively minor compared to other programs. Thus, the task force was perceived as relatively insignificant by much of the agency. Finally, both Hodge and Freitag sought to encourage participation among their staff in the total job.[54]

Despite the task force's looseness, there was a method to the evolution of the working groups. A conscious effort was made to balance the working groups in such a way that most of the centers were represented without any one dominating.[55] The leadership of the major working groups was also balanced across the field centers. For example, the Mission Requirements Working Group was headed by Brian Prichard from Langley; the PPWG was initially chaired by Lee Tilton from the Space Technology Laboratories, and later by Jerry Craig from Johnson; the Operations Working Group was chaired by Frank Bryan from Kennedy; and the CDG was led by Luther Powell from Marshall.

Job assignments within working groups were not rigidly specified, and more often than not people just chose what they wanted to work on.[56] This organization, as Hoban has written, allowed for a great deal of staffing flexibility.[57] New members could work in any or all functions for upwards of thirty days before committing to a single job. In the process, individuals received an overview of most of NASA's activities. This was, of course, partly driven by necessity, since the task force required skilled personnel which in sheer numbers exceeded the agency's capability. After a while task force members with little or no previous experience in varied areas were soon fully participating in the management of those functions. "NASA employees had frequently demonstrated flexibility, but this trait was never more in demand than during the operation of the task force."[58]

With so much flexibility a sense of integration had to be developed among the various working groups. Daily staff meetings conducted by Hodge and Freitag created this integration and became a forum for the exchange of information across working groups and maintained a unity of purpose.[59] In addition to the staff meetings, Hodge established a number of other mechanisms to foster integration:[60] an open door policy, whereby anyone was free to visit him and discuss matters of importance; open meetings that anyone could attend; and open communication between the leaders and staff.

Not all the working groups had been formed at the time Beggs officially announced the establishment of the task force. The Mission Requirements Working Group and the Systems Working Group were the first ones created. In September 1982 the PPWG was created. Then, in April 1983, when it became obvious that the task force would be unable to integrate much of the information generated from other sources, the CDG was established. At this time a support contractor familiar with NASA programs was brought on board to assist with the increasing administrative and documentation load.[61]

The creation of working groups paralleled the significant tasks of the task force which were identified as the work proceeded. Early on it was decided that this phase of the program should emphasize missions instead of space station architecture. This precipitated the mission analysis studies, and its working group synthesized the results of those studies. The PPWG had the responsibility of orchestrating a management and procurement strategy.[62] The CDG grouped the data from the trade studies (and other sources) into sets of functional capabilities to be used in defining potential architectures. It was also influential in arriving at a cost figure for the space station program.

The task force's decision process can be defined as participative: management and staff were allowed input on decisions that directly affected their jobs.[63] The sense of participation and individual

involvement created within the task force spilled over into the senior management ranks: the task force, through the Space Station Steering Committee, brought the associate administrators into the process and enlisted the cooperation of the center directors.

Experiences in the task force were not uniform across the working groups. Due to the unavailability of office space, the CDG, one of the last groups established, was housed a block away from the rest of the task force. Luther Powell, its leader, had the responsibility of designing a functional capability consistent with the $8 billion space station that had been decided upon. Although the CDG was considered to be a remarkable success, Hoban remarked that, "many of its members did not share the same experiences as other task force members"[64] because of the physical separation of the CDG from the rest of the task force.

The Space Station Task Force, despite its participative, open culture, was not without its problems. The unstructured approach of the task force was not hospitable to those who could not function well without structure. Even some very competent people, accustomed to working with defined responsibilities and reporting relationships, occasionally found it difficult to adjust to the dynamics of the task force setting.

Since many of the detailees in the task force were drawn from the field centers, the task force suffered from a constant shuffle of personnel and the accompanying loss of continuity in its deliberations.[65] Some detailees also faced the problem of reentry into their respective field centers once they left the task force, as Hodge had warned many before they joined.[66]

Most of the activity of the task force centered in the PPWG and the CDG. As time went on, it seemed that some of the intergroup relationships were tinged with a spirit of competition, especially between the PPWG and the CDG because the PPWG was led by Craig from Johnson and the CDG by Powell from Marshall.[67]

Accomplishments of the Task Force

The task force operated until April 6, 1984, a period of two years. (On April 6th Beggs established the Interim Space Station Program Office.) During this period it obtained administration and congressional approval of the space station program, completed the comprehensive mission analysis studies, and initiated international participation. It also established several of the premises of the program's management structure.[68]

Of all its achievements, two particularly stand out. First, consistent with Beggs' theme of space station as the next logical step for NASA, the Space Station Task Force brought the entire agency together and involved all the centers in the definition of the space station program.[69] For a while parochial interests were put aside, allowing the task force to function as a single unit for the common good of all the centers. This helped create an internal constituency for the space station that was essential because this program needed all of NASA behind it to make it work. Second, the Space Station Task Force established the planning guidelines for the station for both management and engineering.

The task force accomplished several other things as well. The relationships between headquarters and centers for managing the program were formed during this time.[70] The informal working relationships created through the task force were the basis for other working relationships established as the program progressed.

At the time the task force came into existence, there was internal disagreement over the technological aspects of the space station and the relative involvement of the field centers. NASA needed

to present a unified front.[71] In order to send a consistent signal to those outside NASA, the task force began coordinating its external presentations through viewgraphs identifying a common set of themes. This effort was spearheaded by Terry Finn. Individuals speaking to these constituencies used many of the same viewgraphs and very similar presentations, maintaining a consistency in what all groups were told. Thus, consistency in external presentations was achieved during the Space Station Task Force period.[72]

The task force determined that NASA should be user-responsive both in general and in particular in terms of hardware development.[73] Although Goddard had always been aligned with the scientific community (as a user), the major development centers, Marshall and Johnson, underwent an educational process, shifting the focus of their engineering talents to the users' needs rather than their own.

On the engineering side, a permanently manned presence in space meant that the station had to be continuously habitable and should be able to grow and evolve as needed. This was an innovative idea for NASA. It meant that once the space station had come into existence it would require not only innovative elements for growth, but operational responsibilities such as maintenance, service, and repair.[74]

Finally, the task force assisted in the negotiations with Canada, Japan, and ESA to build the space station. International involvement had been limited in many of NASA's previous programs, especially in hardware development, so the fact that the internationals would be involved in developing hardware for the space station program was to be a new experience.[75] The task force, in its two-year existence, put in place the major management pieces of the space station program (including congressional approval) and assured a future for the program.

Involvement of the Office of Space Science and Applications

As we have seen, Beggs was committed to rejuvenating NASA's scientific and technological capability. Astronomers, planetary scientists, and field particle experts—a major scientific constituency that depended upon NASA—considered the late 1970s to be a "fiscal purgatory."[76] They blamed this condition, in part, on the delays and cost overruns during the development of the shuttle. Beggs, therefore, gave a high priority to revitalizing NASA's space science and application programs, a step that was necessary in order to have this key scientific constituency back the space station program.

In chapter 1 we noted that part of the reorganization undertaken after Beggs and Mark took over created the Office of Space Science and Applications (OSSA) from two existing offices, the Office of Space Science and the Office of Space Applications. For a short time in 1978 Andrew Stofan was the associate administrator for OSSA. When Stofan became center director at Lewis in 1982, Beggs invited Burton Edelson, a long-time friend, member of the Reagan transition team, and a former senior vice president of Communications Satellite Corp. (COMSAT), to head up OSSA.[77]

Burt Edelson knew he was perceived as a NASA outsider when he took over at OSSA. He believed that his engineering background would be viewed with suspicion by NASA's scientific community. How could an engineer, dedicated to the development and design of hardware, fully appreciate the scientists' long-term research interests? He quickly realized that he would have to build his own credibility within NASA and with the external scientific community.

Edelson was keenly aware of the commitment of Beggs and Mark to build the space station. He had to help rally the agency, especially the scientists, behind this initiative. According to Edelson, Beggs'

concept of the space station lacked specificity, but this was an opportunity for the scientists to become involved in an important initiative. When Edelson took over, however, all indications were that the scientific community was unfavorably disposed toward the space station. Edelson himself had to campaign to convince the scientists to support the station.[78]

Edelson's work ran parallel to the Space Station Task Force's activities. As soon as he became associate administrator, he wrote to the center director at Goddard and the director at JPL to solicit their opinions on the space station program. How could it be used to further the interests of the space science and applications group? Shortly after he wrote, however, both men resigned their positions and left the agency.

Edelson's next move was to involve the science community outside NASA. The older disciplines—astronomy, space physics, and earth sciences—were independent. Scientists from these disciplines viewed the space station as a fairy tale. By contrast, scientists in the younger disciplines (i.e., the life sciences and microgravity) seemed to enjoy a relatively higher degree of success with the space shuttle and were more favorably disposed toward the station.[79]

In his effort to win the external scientific community, Edelson wrote to the chairmen of the Space Science Board (SSB) and the Space Application Board (SAB), inviting them to study how the space station could be utilized. Their initial responses were mixed. The Colorado meeting of the SSB, in October 1983, could not determine users for the space station. The participants indicated that none of the scientific projects that they had planned for the shuttle was planned for a space station.[80] Consequently, as far as the SSB was concerned, there was no need for a space station. The SAB was more forthcoming. In Edelson's words, "they did a real study, produced a brochure, and built on the idea of the polar orbiting and unmanned platforms."[81]

Meanwhile, the Space Station Task Force had taken shape under Hodge, who had earlier paved the way for user involvement by emphasizing missions and restricting task force members from delineating design details of the station. As the task force went to work, a set of mission analysis studies looked at how the space station could be used. But what were the needs of the users? Edelson had written to Hodge, noting that the mission analysis contractors should not just be aerospace companies, and Hodge agreed (he did not want to exclude anyone desiring to be involved). As the various studies were conducted, therefore, Hodge included TRW, one of Edelson's recommendations, to be a contractor. In addition to influencing the contractor studies, OSSA was also involved indirectly in the task force: members from Goddard and JPL participated in its deliberations. Edelson was officially a member of the Space Station Steering Committee, composed of associate administrators, which served as a reference point for agency-wide concerns on the task force's progress.[82]

The SSB's lukewarm response did not deter Edelson from pursuing scientific constituencies for the station. He developed four studies, which formed a foundation on which to base further constituency-building initiatives. Edelson then invited a committee, headed by Peter Banks of Stanford University, to review the four studies and make recommendations on how the station could be utilized for scientific purposes. The Banks Committee conducted a number of additional studies with subgroups drawn from various disciplines and over time was instrumental in developing concepts for effective scientific use of space station architecture and in publicizing the benefits of platforms and modules in the station.[83] The idea of polar platforms subsequently caught on with the earth sciences community, which began to see the synergy that could be built into missions and instruments.

Enthusiasm over the polar platforms was not confined to scientists in the United States. The international scientific community also became avid supporters, due in part to the international collaboration that Beggs had strongly advocated. Domestically, organizations such as the National Oceanic and Atmospheric Administration (NOAA) understood that the space station could perform the tasks of more expensive weather satellites in a more cost effective manner. Other agencies, such as the United States Geological Survey and the Environmental Protection Agency, also became interested in using the orbiting platforms.

Over time Edelson's job became easier, as he succeeded in getting the budget increased for such programs from $900 million to over $1.5 billion. He believed that this was a way to convince NASA's scientific community that he was enthusiastic and committed to their programs, especially in light of the perception that he was an outsider.[84] The media noticed Edelson's success in promoting NASA's science budget. In late 1982, various articles suggested that NASA's planetary sciences were on the rise after the dwindling science budgets in the 1970s.[85]

The Spacelab missions in 1983, which demonstrated to the microgravity and life scientists the benefits of conducting research in space, also facilitated Edelson's job. Spacelab dramatized the potential for solar observation as well. Such successes, carefully noted by the scientists, gave the space station a measure of acceptance in the scientific community.

Of course, the space station initiative remained uppermost in the minds of Beggs and Mark. So, as Edelson nurtured NASA personnel, he had to do so within the framework of their initiative. Thus, the scientific programs that he helped establish had to be developed within this major NASA initiative. For example, within OSSA, an ongoing study focused on combining LANDSAT, SEASAT, and WEATHERSAT into a single operation. Edelson's presentation to Beggs and Mark, describing the potential of the combined operations, took place in 1983. This combined operation would have cost $1 billion in the 1990s. According to Edelson, it was a brilliant presentation, but at the end Beggs and Mark privately counseled him not to undertake any major initiatives that might hinder the approval of the space station program.[86] As it turned out, Edelson turned the initial disappointment over the SAB studies into an opportunity. The elements of the study he had advocated were later incorporated into the station plan.

Edelson himself communicated with the Space Station Task Force in an attempt to increase the representation of the scientific community. Perhaps more important, Edelson established close working relationships with both Culbertson and Hodge. Formally, he transmitted SAB reports, Banks' committee deliberations, and results of the Spacelab in memos to Culbertson and Hodge. Despite their differences, their contacts during the constituency building days, on the whole, went smoothly.[87]

Edelson's biggest impact on the space station program was through building external scientific constituencies. He influenced task force deliberations primarily through the communication channels that he established with Culbertson, Hodge, and the members of the NASA scientific community represented on the task force. Most of the external committees were funded by OSSA, which helped create a climate for the station's approval. Edelson blunted the criticism of the space science community and enlisted the assistance of some within that community. This was undoubtedly the major accomplishment of his initiatives.

Edelson also worked to bring NASA's scientific community into the space station program, but had only mixed success. There was some support, but NASA's premier scientific centers felt that more could have been accomplished. Kenneth Frost, then deputy center director at Goddard, for example, noted

that enthusiasm over the station was confined to the associate administrator's office, and that many at Goddard had a relatively hard time adjusting to it.[88] Noel Hinners, the director at Goddard, felt that Goddard's involvement was not nearly what it should have been.[89]

OSSA also played a part later in detailing and prioritizing the space station requirements for the requests for proposals (RFPs) during the detailed definition phase (Phase B studies). These requirements ranged from servicing and maintenance capabilities to polar platforms, life and microgravity modules, attached payloads, and co-orbiting platforms. According to Edelson, however, the role of OSSA in defining the station's requirements was less than what he would have preferred,[90] although OSSA did contribute to several concepts used in the station. The idea of the unmanned platforms, especially the polar orbiting platform, can be attributed to OSSA's initiatives and were also advocated in the Banks Committee's studies.

Finally, OSSA's key role was not confined to early space station initiatives. Subsequently, when the Phase B RFPs were debated, OSSA contributed its own point of view, which we will explore later. In short, one of OSSA's lasting contributions centered upon its activities, in conjunction with those of Beggs, to convince an initially lukewarm scientific community to support the space station program when it was presented for approval to the White House and the congressional committees.

Presidential Approval

> When President Reagan gave his State of the Union Message on January 25, 1984, he said, in part:
>
> America has always been the greatest when we dare to be great. We can reach for greatness again. We can follow our dreams to distant stars, living and working in space for peaceful, economic, and scientific gain. Tonight I am directing NASA to develop a permanently manned space station, and to do it within a decade.[91]

Now NASA could build the station.

How, in 1984, did NASA get Presidential approval for the space station program when so many previous attempts had failed? The economic climate of the 1980s was no better than that of the 1970s. Intensive congressional oversight persisted. The scientific community was skeptical at the outset, and the DOD had chosen not to participate with NASA in this venture. And no one could accuse David Stockman, Director of the Office of Management and Budget, of generosity toward NASA. Against such formidable odds, the agency had won a major victory, one that NASA would cherish for years to come.

From a management point of view one can find four key reasons for the success of the initiative: the role of the President, Beggs' strategy for the space station, the role of the Space Station Task Force, and OSSA's management of external committees.

Historically, Presidents of the United States, with few exceptions, have not been comfortable with science and technology. As a consequence, most presidents since John F. Kennedy have not had science advisors in the White House. Was Ronald Reagan different? According to Jim Beggs, indeed he was. Reagan quickly grasped the significance of the space station program, and Beggs interpreted for him the importance of the initiative.[92]

Beggs' style and strategy, and that of his deputy, Hans Mark, also played a role in the success story. Both had excellent political connections, formal and informal, in Washington. Externally, Beggs adopted a low key style, patiently waiting for his constituencies to support the program, and quietly explaining the program's importance to the President. Beggs was thus able to counterbalance the space scientists' initial hostilities. Under his leadership, NASA invited Canada, Japan, and ESA to join the program,

although the programmatic specifics were left unclear. When DOD parted company with NASA, Beggs did not hesitate to go to the President.[93] Approaching the President directly was a strategy that had failed once before, and carried with it the risk that influential government agencies would disapprove and withhold support for NASA. In retrospect, the risk was well worth taking.

Perhaps Mark's greatest contributions to the approval of the space station was that he backed Beggs (through effective lobbying in Washington) in making the station their number one priority. Mark also helped set up the initial structure for the space station program at headquarters through Culbertson, the Fletcher Committee, and the Space Station Steering Committee.[94]

Beggs' leadership style permitted the Space Station Task Force to operate as a vibrant part of the effort to win the program's approval. The task force's location at headquarters minimized NASA's intercenter rivalries. Under Hodge's democratic leadership, the Space Station Task Force projected the appearance of unity to outsiders. As we elaborated earlier, the task force's emphasis on missions and agency-wide involvement helped keep the internal struggles (among the centers) in check. Further, with external representation coordinated through both NASA personnel and the task force an image of internal harmony was projected.

Finally, NASA's external committees became effective advocates of the program. The Fletcher Committee, the first such committee to be appointed, recommended a subtle approach to "selling" the program. The external committees of OSSA reduced the initial antagonism of the scientific community. Edelson, for example, argued that the Banks Committee eventually became a more effective advocate of the program among the space scientists than NASA itself.[95] Despite significant opposition from space science, a group of scientists came to support the space station program. This in itself was an impressive achievement.

PART II

DESIGN OF THE MANAGEMENT EXPERIMENT

CHAPTER 3

MANAGEMENT AND PROCUREMENT STRATEGIES

Even in early 1982, deliberations had begun at headquarters regarding the management and procurement strategies of the space station program once the initiative was successful. Management strategy referred to organization structure, allocation of work and responsibility, and phasing of the program. Procurement dealt with issues of contractor involvement. The early discussions focused on the diversity of the field centers, management structure, NASA's experience with the location of program management in the Apollo and shuttle projects, and the recommendations of the recently completed Hearth Committee Report. These four factors also affected the deliberations held within the Program Planning Working Group, a part of the Space Station Task Force.

The Centers

Since its creation in late 1958 NASA has evolved into a complex organization with multiple field centers, each with its own unique expertise, organizational heritage, and way of conducting business. NASA's predecessor was the National Advisory Committee for Aeronautics (NACA). NASA inherited from NACA the premier aeronautical research and technology centers of Langley, Ames, and Lewis.[1] After NASA was formed, Goddard Space Flight Center was added, focusing on scientific research, particularly space astronomy and space physics. The von Braun rocket team in the 1950s had been housed at Redstone Arsenal in Huntsville, Alabama, a part of which later became the Marshall Space Flight Center. Marshall later won acclaim as an engineering center. With the big thrust of the Apollo project during the Kennedy era, NASA built up two development centers, Marshall and Johnson Space Center. Because the astronaut contingent was located in Houston, Johnson became the flagship center for the manned elements of the space program. Throughout the 1960s and 1970s, the technology and research centers were seen as centers for unmanned programs and the development centers were viewed as the centers for manned programs.[2]

Although each center worked on development as well as research, each had its own areas of expertise. Langley, Ames, and Lewis focused on the development of advanced technology and became advocates for continuing innovation of the technology available to NASA's major programs. The development centers, Marshall and Johnson, were engineering oriented, focusing on the deployment of existing technologies for manned elements of the space programs. The leading science center, Goddard, was involved with the scientific community, responding to scientists' needs rather than only focusing on operations.[3]

NASA Management Structure

Over the years, NASA had evolved a three-tiered structure for managing significant programs within the agency. The first tier, which might be described as the institutional tier, was responsible for general oversight, directing studies, and performing the functions required by NASA in its interface with Congress, the White House, and the Office of Management and Budget, and insulated program management from the political pressures of Washington.[4] The second tier, program management, coordinated the projects carried on in the various field centers. The third tier, the project offices, were usually

located at the field centers and managed the contractors who did the development work but fell outside the boundaries of NASA's organizational structure.

Apollo and Shuttle Projects

NASA's missions expanded during the 1960s and 1970s, and the diversity of the field centers increased as well. Before the Apollo Project, NASA's primary focus was on research in science and technology. With Apollo NASA became intimately involved in major development work in a manned program. Developing the Space Transportation System (STS), with its shuttle orbiter, brought operational involvement to NASA. Although there have been selected efforts to find outside organizations (private sector or joint, as in the case of COMSAT in its early days) to take over the operations of the shuttle so that NASA engineers could concentrate on innovating, rather than operating, such efforts have been largely unsuccessful.[5] These changing missions have meant that NASA has moved from its original NACA tradition of research in technology and science into development work and, finally, into operations.

NASA employed different management structures in the Apollo and shuttle orbiter projects. Although the major programs all consisted of three tiers, there were differences in terms of relationships among the tiers and their locations within the agency. Apollo was managed from headquarters. This meant that the Washington office had not only responsibility for the first tier, interfacing with Congress and the White House, but also for the second tier, i.e., program management.[6]

After 1969, following the Apollo project, the economic climate became increasingly austere, and NASA's labor force decreased significantly. It was difficult for headquarters to carry out political leadership and program management functions simultaneously.[7] In addition, increasing congressional oversight throughout the 1970s meant that headquarters had to focus more and more on politics and less on management. As a result, program management functions began to be delegated to the field centers.[8]

In the shuttle project the lead center concept was employed, with the program management function located at one of the centers. Application of the lead center concept also implied that one field center would direct the activities of other centers with respect to the program at hand.

The use of a lead center in the shuttle project was a matter of expedience and necessity rather than the belief that it was the ideal form of organization.[9] The shuttle project involved major development work, did not have much user interaction, and had what came to be known within NASA as clean interfaces. Clean interfaces meant that the work could be split into more or less self-contained units that could be handled at separate centers.[10] Furthermore, in a time of tightening budgets, it seemed more efficient to put field center people to work on the systems engineering and integration task, those tasks for which the development centers of Marshall and Johnson were very well suited. The lead center concept seemed appropriate for the changing circumstances of the shuttle project and the environment in which NASA operated.[11]

In 1982 NASA consisted of a relatively mature work force, and many remembered the Apollo days. The shuttle, of course, was also fresh in their minds because it still involved the agency's developmental and operational activities. As a result, two alternatives of organizing a program were known to NASA employees.[12] These options were 1) the Apollo model of organization, whereby headquarters had the role of program management in addition to its political tasks; and 2) the shuttle model of the lead center

concept, whereby the program office was separate from headquarters and managed out of a field center (in this instance, Johnson).

With budget overruns and schedule delays in the shuttle project, many Apollo veterans looked back to Apollo as an example of the "good old days."[13] To these individuals the direction from headquarters was a necessary prerequisite to effective program management because intercenter coordination cannot be accomplished by any one center alone. To others, who had observed the increasing political pressures on NASA and the reduced budgets that went along with it, the decentralization via the lead center concept represented the best way of managing multicenter programs.[14] They believed that technical work could not be performed effectively in Washington, D.C. At the beginning of the space station program, the lead center idea was widely accepted at Johnson, which had accumulated "sufficient" experience in the application of this concept in the shuttle.[15]

Although the shuttle contractors were not involved in resolving management issues with respect to the lead center approach, they felt that the way the lead center had been assigned for the shuttle had affected their chances to win hardware contracts.[16] For example, the detailed definition (Phase B) for the shuttle was conducted before the lead center was designated. As a result, when a single contractor was chosen for the shuttle's development at the conclusion of the definition phase, many contractors felt that Rockwell won because it had worked closely with Johnson. Contractors such as McDonnell-Douglas, therefore, were always concerned that postponement of the lead center decision until after the definition studies would adversely affect their contract's chances of acceptance.[17]

The Hearth Committee Report

The space station initiative was affected by another major event at NASA, the Hearth Committee Report.[18] This committee, which was formed in response to congressional concerns regarding cost and budget overruns in NASA programs during the late 1970s, was headed by Donald Hearth, then center director at Langley, and consisted of personnel from through NASA. The Hearth Committee investigated fifteen projects (not including the shuttle) and concluded that as the management interfaces within programs increased in complexity, the tendency for budget and schedule overruns increased correspondingly.[19] The Hearth Committee recommended that a detailed definition phase (Phase B) be included in any major program. Prior to this, the Phase B studies had been conducted in a short period of time, and had sometimes led to multiple definitions, often extending into the design and development stage. As the Hearth Committee recommendations were introduced in 1981, they provided a backdrop to space station program deliberations.

Program Management Decisions

The diversity of the field centers, the three-tiered model of organization, the memories of the Apollo and the shuttle program management, and the Hearth Committee recommendations all influenced the members of the Space Station Task Force as they began to deliberate the management and procurement strategies for the station in early 1982. The deliberations were conducted in an atmosphere of uncertainty. No program existed because presidential approval had not yet been given. John Hodge had directed the members of the Space Station Task Force not to draw any pictures of the space station so no one would attempt to design the space station prematurely.[20] The mission analysis studies had just started, and the system requirements were being refined by one of the working groups associated with

the task force. Even though management deliberations occurred during this period, nobody knew the nature of the program they were going to manage.

Although it was not directly obvious to many members of the task force, the convictions of several top NASA officials had already been formed. These became crucial factors in major management decisions later on. Deputy Administrator Mark had been a center director at Ames, was extremely sensitive to the changing political circumstances, and believed that much of NASA's technical expertise lay in the centers. He preferred that the program management be located at one of the field centers and felt that headquarters' real function was to persuade the other centers to work with the lead center, not manage the program itself. He also believed that headquarters should represent NASA in Congress and with other governmental agencies, and should also develop and formulate programs. Once the decision had been made to go ahead with a program, according to Mark, then the centers should be responsible for actually managing the project.[21]

In retrospect, it is apparent that Mark's convictions were not shared by Hodge as the task force was formally organized in May of 1982. As a result, as Hodge began to consider program management, he thought several alternatives needed to be developed and debated. In July 1982, just two months after the formation of the task force, Hodge identified the major management issue confronting the space station program: to develop procurement and management strategies.[22]

Even in these early days most NASA personnel accepted the three-tiered concept envisioned for the program. The first tier, looking out and directing, would be Washington's job. The third tier, in charge of directing the work of the contractors, would be located at the field centers. However, there were questions about the location of the second tier—to be called Level B—which was to take charge of program management.[23] Should it be located in a science center, a technology center, a development center, or at headquarters? If it was to be a science center, then it would be Goddard. If it was a technology center, then it had to be Langley. If it was a development center, then it could be either Marshall or Johnson. Or perhaps program management could be at a new center, or at headquarters itself. Hodge felt that if the lead center concept was chosen, the centers would not work for each other. They would say they would, but they really wouldn't. And he believed that NASA's previous experiences indicated that he was correct.[24]

In early 1982, the media had hinted at major changes in NASA's organization. The problems with shuttle and the space telescope had drawn particular attention, and the task force members considered this when they discussed the organizational structure for the space station.[25] First, they explored the idea of creating another center. That didn't seem like a good idea, so they then looked at creating a sort of "center within a center." That idea was also rejected. "And then we sort of came up with the idea that we would take a neutral center and put the program office in that center but have it report to headquarters."[26] According to Hodge, it did not matter which center housed the program office as long as it reported to headquarters. "We could have it in Houston at Level B. To me it would have been perfectly okay if it reported to headquarters."[27]

During these early discussions, Culbertson, Hodge, Robert Freitag, and several other task force members, including Terry Finn, were involved. Although Hodge had not taken a position on the location of program management, by September 1982 some in the task force believed that Culbertson had decided to put Level B at Johnson Space Center in Houston.[28] The political fallout of such a move was not lost on the task force members. Finn argued that it would be premature to cut Marshall out of contention for the lead center. If the Alabama Congressional delegation learned about this decision, they

might withhold support for the space station initiative. In a memo that came to be known as "Don't Deal Marshall Away," Finn stressed that Marshall personnel should have an opportunity to present their reasons why the assignment should not go to Houston, to respond to what were perceived as Marshall's shortcomings, and to tell why Marshall should be assigned Level B responsibility for the new space station program.[29]

The Program Planning Working Group

The task of detailing the procurement and management strategies for the space station program fell to the Program Planning Working Group (PPWG), one of the subgroups within the task force. Because of the importance of program planning, this working group was chaired initially by Freitag, Hodge's deputy. He later delegated this responsibility to Lee Tilton, reserving for himself the chairmanship of the Program Review Committee.

Tilton had not participated in any of the earlier discussions concerning organizational structure, including those on the lead center concept. As a result, when he took charge of the PPWG he did not ask if the lead center would be at Houston, but whether there would be a lead center at all. And he dealt with other major management issues as well. "One was the lead center issue, that was a big one. Another one was the way to divide the program. The third was how the program should evolve over the phases."[30]

The PPWG under Tilton consisted of personnel from headquarters and all the field centers except Langley and Ames. The PPWG did not report directly to Beggs, but instead interacted with Hodge, director of the task force, who had frequent contact with Beggs. Hodge interpreted Beggs' thinking for the PPWG. Accordingly, even though the PPWG did not communicate with Beggs directly, Beggs' views were known and influenced many of their decisions. It was clear to the PPWG that the major tasks of the space station program required a combination of NASA personnel and contractors. Thus, by specifying the functions of the program office it also identified the activities of the contractors, and vice versa.

Two other factors also had to be considered: the guidelines under which the management and procurement strategies had to be orchestrated, and the timing of these strategic decisions.[31] By September 1982, the guidelines had already been defined by Hodge, Beggs, and Mark, and Hodge had communicated them to the PPWG (see figure 1). They included the program's characteristics, the evolutionary capability of the $5-10 billion limit, and the specific budget constraints for the three ensuing fiscal years.[32]

The Space Station Task Force had assumed that it would be out of business by September 1983, and the definition contracts would begin by November of that year. This was not to be the case.[33] Nevertheless, the PPWG began its deliberations based on this early approval date. If the program was to be approved in a year, internal management decisions had to be made by the time the definition contracts started. This lent urgency to the PPWG's activities.

Since the constituency-building for the station paralleled the PPWG's deliberations, the PPWG did not have the benefit of a configuration on which to base the program's definition phase. Tilton explained:

> In the requirement studies Hodge forbade contractors to draw a picture of the space station. Nobody was to do anything or say anything about what a space station was. The only issue was why do you need to have people permanently in orbit? What are they going to do? What would

Space Station Planning Guidelines

MANAGEMENT RELATED

- Three year extensive definition (5-10% of program cost)
- NASA-wide participation
- Development funding in FY 1987
- IOC in 1991
- Cost of initial capability: 7.5-9B
- Extensive user community involvement
  - --Science and applications
  - --Industry
  - --DoD
  - --Commercial
- Possible international participation

ENGINEERING RELATED

- Continuously habitable
- Shuttle dependent
- Manned and unmanned elements
- Evolutionary
- Maintainable/restorable
- Operationally autonomous
- User friendly
- Technology transparent

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Figure 1

> the facility do that would serve them? What kinds of functions would it perform? What products, what activities? That was all. Nobody could draw any pictures of any space stations because as soon as you draw a picture you could start to conjure up in your mind what the thing is and you revert back into the engineering situation where we say we're going to build that neat looking thing there, and we will figure out later what it is supposed to do.[34]

The PPWG deliberations reached several conclusions. First, the management strategy would affect the role of the field centers and headquarters and the way they related to each other. Second, an early launch option was not feasible because it would mean that the contractors would have to be brought on board prematurely. If that happened, the Hearth Committee's recommendation for the detailed definition period would have been disregarded, and NASA might revert back to its old way of conducting business, which the Hearth Committee had roundly criticized. Third, the systems engineering and integration function was important in the management strategy.[35] These deliberations raised more questions relating to the systems engineering and integration (SE&I) function than they answered, however. Where should this function be located—at headquarters or the field centers? Should a contractor assist the program office in this function? Should the function be performed primarily in house or be contracted out entirely?

The PPWG was concerned with alternatives for staging the program over phases.[36] Although four different options for space station program phasing were considered, the option including an expanded definition phase was preferred. This decision was an outgrowth of the Hearth Committee's earlier recommendations.

One of the major factors affecting the discussions of procurement strategy was Beggs' decision that any strategy that focused on a single prime contractor was unacceptable. Beggs reasoned,

> When you build a building or build a house you have a general contractor. The general contractor in this case was going to be NASA [because] NASA knows better than anybody we could hire what should go into the space station and what its requirements should be. Then we hire the subcontractors, in effect, to come in and do that work. I felt sooner or later we would have to take on a systems contractor, somebody outside who would be able to do the systems design and system conceptualization activity, because, while NASA is pretty good overseeing work done, complex things, they are not terribly good at the detailed system analysis or design work. So I felt that sooner or later we would take on a systems contractor, but first I wanted to get the thing off the ground.[37]

Beggs did not want only one contractor for another reason. He had always maintained that NASA would build the space station by the yard. It was important, therefore, to keep NASA's constituencies on its side for a considerable time. If one contractor was selected quite early in the program, then some of the constituencies (other contractors, for example) might show little interest in supporting the space station over the program's later phases. As Beggs explained, "I certainly was not unaware of the political power of the geographically spread contractors."[38] Beggs felt it would be advantageous to maintain the interest of a large group of contractors rather than commit to only one early in the space station program. This was especially important if the station was to be constructed by the yard. Thus did programmatic reasons complement constituency concerns:

> [In the case of the shuttle project], there is no alternative source. Therefore the administrator cannot threaten Rockwell. No one else could. ... [This means] there is no other source of information: if you ask a question, if somebody within NASA doesn't know the answer, there is no place to go [except the contractor]. So we've got no alternative information source. You've got

no way of knowing whether it is a carefully thought out answer, a hasty answer, or even an outright lie. You've got no choice but to believe what the contractor tells you.[39]

Systems Engineering and Integration

In his confirmation hearings Beggs had indicated that his goals for the agency included revitalizing its engineering capabilities. Unlike the shuttle program, the station program's systems SE&I function was to be performed in-house, possibly with the help of a support contractor. This underscored Beggs' goal of revitalizing the technical capabilities of the agency as well.

The job of outlining the SE&I function was given to Jerry Craig, a member of the PPWG from the Johnson Space Center.[40] He could not help but be influenced by the Apollo and shuttle projects, although SE&I functions in these two had been performed differently. In the case of the Apollo project, a single SE&I organization was responsible for the total system and was completely within the program office at headquarters. In the case of the shuttle, the SE&I organization was part of Level B (located at Johnson), and, therefore, SE&I was primarily conducted and managed by Johnson personnel. The shuttle project involved three field centers, Marshall, Johnson, and Kennedy. The hardware development took place at Marshall and Johnson, while Kennedy launched the shuttle.

The systems engineering function in the space station program was anticipated to be more complex than the earlier projects. As envisioned, the station would incorporate manned and unmanned elements and would have a capability to grow and evolve. The international involvement significantly added to the complexity of the SE&I job.

Craig delineated two options for SE&I. In the first, headquarters managed and conducted the SE&I function; in the second, the center with the lead center responsibility managed SE&I. At this stage he assumed that in either option a support contractor would be hired, as had been the case in Apollo, where Bell Communications had supported the SE&I function.[41]

Although the PPWG was not authorized to make any decisions, it stressed the difficulty of locating the SE&I function at headquarters. If SE&I were located at headquarters for the space station program, the number of technical personnel located there would have to be increased significantly. To do this, NASA would have to move qualified civil service personnel from the field centers to headquarters.

Systems engineers were among NASA's most prized talent.[42] Since all the field centers were involved in ongoing programs, the systems engineers at each center were valued quite highly. If these civil servants were brought to headquarters, it could only be done with the cooperation of the center directors, who would have to relinquish their most valued resources to the space station program. Thus, the internal political question remained: would the center directors give up their systems engineering talent to benefit the space station during the definition phase?

Advanced Development

As a part of the space station program management, the PPWG deliberated over the role of the space station advanced development. In 1982 the SSTSC had developed a position on the station's technological development. Advanced development of technology had to be an integral part of the entire program.[43]

The problem of addressing the management of advanced development was given to Ron Thomas, a member of the PPWG from Lewis, one of the technology centers. Thomas presented three options:

1) the Space Station Task Force would manage the program by itself; 2) the task force would share the management with the Office of Aeronautics and Space Technology (OAST); and 3) OAST would be responsible for meeting the station's advanced development requirements. Thomas apparently favored the third approach.[44]

In early 1983, Tilton handed over chairmanship of the PPWG to Jerry Craig. Craig had been sent to Washington to lead the Johnson detailees and to take a stronger position for Johnson in the task force.[45] A perception existed that Johnson was not participating in the task force, and Craig hoped to change it. He was quite successful, bending over backwards not to be too opinionated in favor of Johnson's position. Before long others came to him "asking for advice and counsel and how should we do this, can you get the guys down at Houston to help us with this and so on." This was entirely different from when Craig first went to Washington.[46]

Under Craig's stewardship, the PPWG produced a white paper exploring NASA's organizational choices with respect to the SE&I function.[47] Beggs' earlier decision not to have a single prime contractor had eliminated the option of relegating SE&I to an outside contractor. Therefore, NASA had to locate SE&I either at headquarters or at one of the field centers. If the SE&I function was located at one of the centers, then that center de facto would be the lead center.

Accomplishment of the Program Planning Working Group

The PPWG focused exclusively on the programmatic aspects of the space station to the exclusion of institutional factors that later dominated the decisions related to organization and management. However, in presenting the programmatic perspective, the PPWG accomplished several things.[48] First, it identified the guidelines for engineering and program management. Second, the various phases of the program were identified, including requirements and analysis, definition, development, and operations. The PPWG emphasized the need for an extended definition phase for the program.

Third, the PPWG outlined options for resource management—how the budget could be allocated across various levels of the program and over the phases. Although some options were discarded later on, these became the basis on which judgments could be made. Fourth, a number of acquisition approaches were identified for the three program phases. The advantages and disadvantages of four basic approaches were studied and evaluated, and narrowed to two. The first option was similar to the one employed in the space orbiter project. In the second option NASA kept systems engineering and integration and definition of development level requirements in house. NASA subsequently adopted the second approach.

And finally, the PPWG clarified the activities involved in the management of the program, including SE&I. The PPWG refined the management options confronting NASA, one with headquarters in control, and the other the lead center concept.

Although the PPWG did not have the authority to make decisions, it influenced the program for years to come by its work in selecting and refining options and presenting them to the institutional leadership for adoption. Decision-making is often characterized as selecting from a set of alternatives. The process, in reality, is far more complex and involves setting up premises, defining, comparing, and choosing alternatives, and implementation. Viewed in this context, although the PPWG did not adopt a specific option, its legacy to the space station program consisted of refining the alternatives that would be debated by NASA's institutional leadership.

CHAPTER 4

BROADENING INVOLVEMENT IN SPACE STATION PLANNING

As the Program Planning Working Group (PPWG) explored options for managing the space station program, other discussions were taking place at headquarters and the field centers. These discussions dealt with the part NASA's leadership—the administrator and field center directors—would play. Although the program had not yet been approved, the agency's leaders began to see how important their management decisions would be. The center directors were very aware that with management came decision-making authority and control of resources.

As we have seen in chapter 3, the viewpoint of the deputy administrator, Hans Mark, had already been formed, although it was not immediately seen by the task force. At headquarters discussions regarding program management initially took place between John Hodge, the director of the Space Station Task Force, and Phil Culbertson, the associate deputy administrator.

It was apparent by this time that Culbertson preferred the lead center option.[1] From the programmatic point of view, however, Hodge felt that Washington should be in charge of the program management during the definition period.[2] Culbertson pointed out the lack of essential technical resources at headquarters, while Hodge maintained that it was impossible for a lead center to be objective because there was likely to be a conflict of interest.[3]

Hodge had at one time proposed other options for program management. One was to locate the program management at Goddard Space Flight Center. Since the program was to be user-driven, and since Goddard was closer to the scientific community, the choice of Goddard made programmatic sense.[4] Hodge had approached Noel Hinners, the center director at Goddard, to discuss locating the program management function there. Hinners discouraged the idea because physical space was limited at Goddard, and the space station program was considered, at least by Hinners, to be "a minor element of the work at Goddard, not a major one."[5]

As Culbertson and Hodge wrestled with the question of where to locate program management, they first tried to find a compromise. One option offered was to locate the function at a center which did not have development responsibilities. Such a center would not be perceived by other field centers as having a bias in decisions involving the development of the space station. If this option were to be adopted, Culbertson and Hodge agreed that Langley Research Center would be the logical choice. Culbertson talked with Donald Hearth, Langley's center director. Culbertson noted that Hearth was not particularly eager to have Langley house Level B, "but he said he would do it if the agency asked him to."[6]

Langley seemed to be an ideal place to locate the program management. There would be no development responsibilities assigned to Langley, and the center had a longstanding and excellent technological reputation that dated back to the NACA days. It was not clear, however, whether program management would remain at Langley for the duration of the program. It was generally understood that the program management office would be located there for at least the length of the extended definition period, or 18 months to 2 years.[7] It was not clear what would happen after the extended definition period. Langley would have some 50 to 100 of its staff involved, however, and if the lead center were moved after the extended definition period, then Langley might lose those employees.[8] That would be disruptive at Langley and cost them personnel as well.

In addition to the instability that might be created by shifting personnel, it seems that Langley's background may have influenced Hearth as well. Langley's capabilities lay primarily in technology development, and only secondarily in development activity. In addition, some of Langley's previous experiences in development work did not make Hearth eager to take on any more such work.[9]

Other center directors were also defining their positions at this time. As soon as he became the director of the Lewis Research Center in 1982, Andrew Stofan instituted a center-wide planning process to lay the groundwork for Lewis' involvement in the space station program. Strategic planning at Lewis had been completed by the beginning of 1983.[10] Lewis personnel wanted the center to be involved in space station development work. According to Stofan, Lewis would bid for development work related to power in the space station program.[11]

Stofan knew Lewis was not perceived in Washington to be a development center. This perception persisted despite Lewis' involvement in the development work on Atlas and Titan (major Air Force programs). In his opinion, the assignment of space station power systems to Lewis could do the most to change this perception. He didn't feel Lewis could handle the lead center job, especially with little support in Washington, so he chose not to pursue that assignment.[12]

As discussions about space station management continued, Gerald Griffin,[13] the center director at Johnson, considered that center's involvement. Johnson was, at that time, heavily involved in the shuttle. NASA personnel had always considered the "five barons" of Johnson Space Center to be powerful figures,[14] and in order not to upset the institutional power base at Johnson, Griffin first needed to assess the reactions of these five men before he bid for the lead center assignment. They all met with Griffin to discuss whether they felt Johnson should compete for lead center or not. There was some reluctance and concern, but they all decided that they wanted Johnson to be the lead center.[15] With the institutional support of Johnson behind him, Griffin then bid for the lead center assignment.

Enlisting the support of the organization, however, was different from actually securing the lead center assignment. He needed support in Washington as well. Griffin was not a novice in this and was cognizant of the political pressures within the Beltway. He kept open his channels of communication with Jerry Craig, head of the PPWG. In fact, whenever he went to the Capital, the two met informally.[16]

Griffin recognized that either Marshall or Johnson could handle the lead center responsibility, and either could do it well. He thought Johnson would be the better choice because it had manned system experience and housed the astronauts. During this time Griffin worked around the agency and at headquarters to establish support for Johnson as lead center.[17] Meetings at Wallops and Langley took place while Hodge and Culbertson were trying to decide the appropriate location for the program management, and the center directors staked out their positions on the management of the space station program.

During 1983 the task force continued to function as a promotional organization as well as one dedicated to charting out the preliminary details of the space station program. The task force was insulated from institutional concerns and had adopted an exclusively programmatic perspective, although members passed information on to their respective superiors at headquarters and the field centers. Hodge continued working to build the rationale for the station on missions. The mission analysis contract was awarded, and the contractors completed their mission analysis studies by the start of 1983.[18]

By April of 1983 Beggs, with the help of the CDG, had arrived at an $8 billion estimate for the initial operating capability of the space station.[19] This $8 billion figure meant additional problems for

NASA.[20] The station that Beggs wanted, and as Powell had costed it at that time, was already over the $8 billion figure. This left no room for error or adjustment. Because there was no flexibility, costs would have to be tightly controlled during the design and development phase of the station, and only the slightest deviations from cost estimates could be tolerated in the future.

To identify the cost drivers (the few elements of the program contributing the largest share of the costs) for the CDG, Frank Hoban, a member of the task force, felt that the program management community—the real program managers—ought to get together at Wallops and discuss the matter. Once the cost drivers were identified, then the CDG could tackle what should be done about them.[21] At the insistence of Freitag and Hodge, Hoban enlarged the agenda for the meeting to include management-related issues.[22]

In early 1983, Hodge and Culbertson were still not in agreement whether the program management should be at headquarters or one of the field centers. By that time, of course, the task force was beginning to see indications that the program might finally be approved by the White House, and the need for institutional involvement in the program was becoming crucial. Hodge was aware of this fact and delegated the recruitment of institutional leaders to Hoban.[23] The task force members, including Hoban, were quite concerned about the perception of personnel in some centers that they had little to do with the station. Internal constituency building was still needed as well.

Hoban took responsibility for planning two meetings with the help of Louis DeAngelis, who headed the Office of Human Resources and Development in Washington, D.C. The first meeting would involve the deputy directors from the centers and personnel working on various projects and be held at Wallops Island Flight Center in August. The second meeting would involve the center directors and associate administrators and be held at Langley Research Center in September.

The Meeting at Wallops, August 1983

The Space Station Management Colloquium was held from August 29 to September 1, 1983 at Wallops. The main purpose of this meeting, as presented in the briefings, was to determine major cost drivers that could be anticipated, conditions that create those cost drivers, and options available and their implications for managing effectively.[24] The meeting was attended by key members of the project management community at NASA, deputy center directors, Associate Deputy Administrator Culbertson, and the director of the Space Station Task Force, Hodge.

Culbertson posed several questions to the group. How could the costs of the space station program be contained? Did NASA have the in-house capability to handle the SE&I job in the program? How could the agency maximize its resources? What was the most effective interface between headquarters and the centers? What were the implications of user interface and operational considerations?[25]

Management considerations, not cost drivers, came to the forefront in the discussions, however. Part of the reason Hodge had agreed to hold the management colloquium was to gauge the mood of the field centers. This came out loud and clear in the meeting. The clearest recollections of this meeting remaining today is the discussion of the location of program management (Level B).[26] Most participants believed that the locating of management at headquarters, and the major SE&I function included therein, was inadvisable because the technical expertise required did not exist there. The consensus of those present was that SE&I could effectively be assumed by the civil servants without having a major contractor. No center, however, would be able to provide all the SE&I personnel.[27]

As the workshop progressed, the likely magnitude of the program became apparent.[28] However, by the close of the workshop it was clear that the center representatives felt that Level B functions should be located at a center.[29]

The issue of reporting relationships between program management and headquarters was not cleared up at the colloquium either. Although no final decisions were made at Wallops, the preference for lead center for the space station program seemed to have gained widespread acceptance. "They were saying we would rather not work under technical direction from headquarters and the way to make sure that we don't is to do it [the lead center way]."[30]

From headquarters' point of view, however, the lead center concept also posed problems. If the program office were located at one of the centers and reported to headquarters the center director's responsibility for the program would be diffused; he could not be held accountable for the resources that were allocated to program management.[31] The center director could also withhold resources from the project, arguing that it was headquarters' responsibility. It was not clear how the field centers would cooperate with one another, especially when one center controlled the program office. Headquarters, therefore, faced a dilemma: whichever option it selected had severe restrictions.

* * *

The Wallops meeting set the tone for the Langley meeting which followed. As the leaders of the field centers also began to understand the magnitude of the problem, lobbying for the lead center took place in earnest. Ames and Kennedy never wanted the lead center role, and Langley, Goddard, and Lewis had decided not to compete for the lead center. That left Marshall and Johnson to compete for the lead center assignment.

Two factors affected the resulting alliances among the center directors. First, three of the center directors—Andrew Stofan, Noel Hinners, and Gerald Griffin—were Beggs' appointments. In addition, seven of the eight center directors had served time in Washington, understood it, and didn't want program control to be located there.[32] Second, the current projects at the field centers influenced the positions of their directors. By 1983, Stofan had decided to bid for the power system in the space station program. Thus, Lewis would be in direct competition with Marshall for the power module.[33] Goddard and Marshall shared responsibility for the Hubble Space Telescope, which was at the time experiencing serious problems, and Hinners may have been concerned that locating the lead center at Marshall would hurt that program.

As the perception was created that the lead center was the way to manage the program, it also became apparent that there would be only two contenders, Marshall and Johnson. By then Griffin had rallied Johnson behind him in his bid for the assignment. As Griffin surveyed the participants, he concluded that Lewis was likely to support Johnson. Hinners may not have been as strongly supportive, but "since, in some respects, he [Goddard] and Marshall were in competition," Hinners was seen to support Johnson also.[34] Dick Smith from Kennedy had personal connections to both Lucas and Griffin, and could go either way. This left Hearth of Langley, who could be a very important person in deciding where the lead center would go. So Griffin began to talk with Hearth about the lead center assignment.

Although prior to these meetings Stofan had established a forum for the center directors, historically they did not often have a place where they could develop positions on issues of common concern. Stofan and Hinners, the directors at Lewis and Goddard, realized the importance of such a forum.[35] The

stability of NASA lay at the centers since the turnover in Washington often created instability there. Stofan, therefore, argued that since the directors represented 20,000 people and Washington represented only 1,600 people, the centers ought to have major input into the decision-making process. This was achieved by the center directors meeting independently in a process established by Stofan. These were "meetings where just the center directors would get together to talk about common problems." Headquarters did not discourage these gatherings because it was the general feeling that "the center directors couldn't get along with each other because they were all trying to get the same piece of the pie." Stofan knew this was not the case, though, because they had a common "foe," Washington.[36]

The center directors had two broad issues to tackle. The first concerned relationships among the centers themselves. Since the major NASA programs involved cooperation among several field centers and the directors had differing perspectives on the matter of intercenter cooperation, this issue was not satisfactorily addressed in the forum that Stofan and Hinners had created. The second issue before the center directors concerned the relationship of the centers to headquarters, an issue common to all. Because it was a common problem, the center directors spent most of their time discussing this second issue. Stofan noted, "It was very obvious once we had a couple of meetings that the common things became far more important."[37] If this pattern were repeated at the Langley meeting, it would be an opportunity for the directors to make their views known regarding the lead center decision.

The Meeting at Langley, September 1983

Phil Culbertson and the center directors met at Langley Research Center on September 22 and 23, 1983. Culbertson opened the colloquium by telling the group that James Beggs and Hans Mark wanted their collective advice and opinions on the major management issues involving the space station program. Although they were not a decision-making body, Culbertson wanted them to identify the major management issues on which they agreed and disagreed and to make recommendations to Beggs and Mark, who were to join the meeting later.[38]

As part of this process, Hodge presented a program update, outlining the deliberations of the PPWG. Later on, Paul Holloway, deputy director of Langley Research Center, summarized the meeting held at Wallops.[39] At the end of the first day the center directors announced that they planned to meet separately before they met with the main group the following day.[40] To Stofan and Hinners this was merely a continuation of the forum they had earlier established, but it came as a surprise to others attending the colloquium.[41] Some thought the center directors had assumed control of the meeting. Hodge perceived it as the center directors making a deal among themselves based on how they wanted the space station to be managed.[42] Some interpreted this separate meeting to mean that Culbertson had been removed from the decision-making process.[43] Most of these people, however, were not aware of the previous meetings of the directors without the associate administrators or anyone from headquarters.

According to Stofan, the separate meeting was requested so that the center directors could carry on a coherent discussion, one that was not possible in the larger group of at least 30 people.[44] Since the centers were likely to be in charge of implementing the program, they needed to be in agreement on how they were going to handle that implementation.

To the authors' knowledge, no formal records were kept of the meeting's proceedings. However, from comments of some of the major players, a number of issues seem to have been discussed

informally: the $8 billion cost estimate for the program; the role of the lead center; the work packages that might go to each center; and, finally, the reporting structure within the lead center. As Bill Lucas, the director at Marshall Center, recounted it, the major forces driving the meeting were reaction against headquarters and the degree of cooperation that the centers could muster among themselves. According to Lucas, the general sentiment that headquarters should not run the program prevailed over the view that the centers were unable to cooperate.[45] So the question of whether there should be a lead center was easily settled, but not the issue of where to locate the lead center.[46] Hinners agreed, recalling a consensus that having one center be a lead center was preferable to having the program managed totally out of headquarters, although he felt there was a major drawback to that as well. The lead center, once determined, would have budgetary control and determine the direction of the program and the work assignments.[47] Griffin did not believe that he played much of a role in the meeting "because there were guys that were highly respected, like Don Hearth, that stood up and were counted," expressing Griffin's point of view.[48]

At the conclusion of their meeting, the center directors maintained that the responsibility for Level B management and SE&I should be at one "lead center" to which all other centers would report. Organizational unity would increase with the appointment of a single space station program manager, who would be lower in NASA's hierarchy than any of the field center directors. To meet the objection that the program manager would have too little power, the directors insisted that they could substitute a "spirit of cooperation" in place of official centralization.[49]

Gerry Griffin produced what became known as the "barbed wire" organization chart (figure 2) to illustrate the operation of the lead center approach, even though the center directors had not agreed upon the location of the lead center, and both Marshall and Johnson were still competing for that assignment. Upon returning from their meeting the center directors were asked to vote on who should get the lead center. According to Hoban's recollection,

> General Abrahamson started walking around the room, and said, "we're going to vote for who should have the lead center." And Culbertson says, "Abe," you know, "knock that off." Abe replied, "No, no, just for fun, let's vote for who gets the lead center." So, I had a chance to vote, and I voted for JSC because it seemed like the most logical place. If we had to have a lead center, I thought they were very capable of doing the job.[50]

According to Hoban, it was almost unanimous for Johnson. Marshall received one vote even though Lucas abstained. Next, the center directors presented their proposal to manage the program, and this was Griffin's barbed-wire organization, which laid out the program management at a field center. The program management (Level B) would be responsible for coordinating the work of the various work packages.

The associate administrators and headquarters personnel attending the Langley meeting also made their recommendations. They recommended that the Level A program management be placed at the associate administrator level and that a new position be established. The SE&I function would be managed by the Level B center, and Level C would be managed at the various centers.[51]

Burt Edelson, associate administrator of OSSA, summarized the views of the associate administrators on the management of the space station program. Overall, they were not favorably disposed to the lead center concept, especially with program management reporting to a field center director. However, they were keenly aware of the problems created by an organizational structure where the program management in one of the field centers reported to headquarters, as in the space telescope

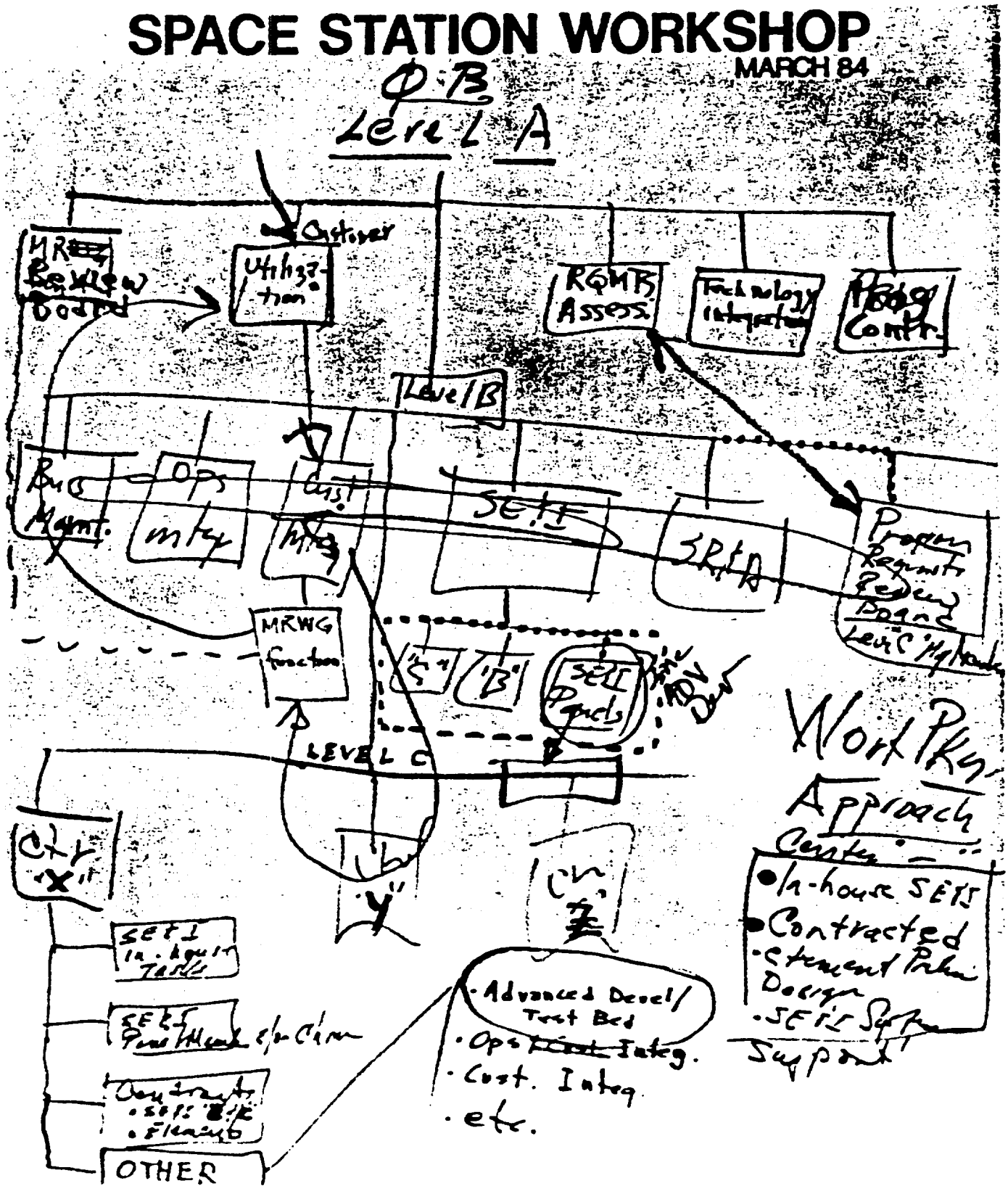


Figure 2

program. The lead center seemed to be the best they could construct under the circumstances. It was a compromise, and Edelson voted for it because he believed it was the best position "under the circumstances."[52]

By advocating the lead center position, the center directors assumed and emphasized several factors. They saw SE&I as the job of the agency, although some support contractors might be required. They emphasized that a center could work for another center, and this meant that each center would provide its share of SE&I personnel to support the lead center. Finally, the directors recommended that a board of directors of field centers should be established for managing and executing the program. In this outpouring of cooperative spirit, the center directors seemed to suggest that they were willing to give up their valuable SE&I talent to other centers, but, in exchange, would control the program through the board of directors.[53]

* * *

Although the lead center recommendation had been made at the Langley meeting, the meeting consisted of personnel who were not empowered to make that decision. Indeed, Culbertson had earlier reminded the attendees that their vote was not binding. The decision was vested with the administrator, and Beggs and Mark were not present during the deliberations. They attended the meeting on September 23rd, and Lucas presented the recommendations to them. Beggs cautioned the participants at that time that they did "not have an approved program yet."[54]

Although the associate administrators and center directors had participated in the recommendations that came out of Langley, Beggs did not formalize the decision until much later. In the interim, he thanked the attendees for a helpful and useful colloquium. He was also appreciative of the "degree of consensus among the group" regarding management issues and findings. He reserved the final decision to himself, of course, and noted that even though they had not officially chosen a management approach, they had taken the first step.[55]

From this process two perceptions emerged that linger today. The first related to how much power existed at headquarters.[56] Given NASA's increasingly decentralized character, whereby the centers had become semi-autonomous, and the fact that the stability of NASA lay primarily at the field centers and not at headquarters, the question of the relative control of headquarters' resources vis-a-vis the field centers had been discussed throughout the 1970s. At headquarters the central players—the administrator, the deputy administrator, and increasingly the associate administrators—were mobile. Tremendous turnover occurred in these ranks: the two top executives were political appointees, and the associate administrators typically went back and forth to the private sector. With headquarters suffering from a "revolving door syndrome," the centers provided the stability.

So NASA had shifted from the Apollo days, where the power lay at headquarters, to a situation where the technical strength resided more and more at the centers. This, to some extent, was accentuated by the fact that the centers had courted specific congressional constituencies in their own regions. Although the NASA field centers usually did not actively lobby their delegations, the congressmen from the districts involved were not insensitive to the presence of the field centers. This enhanced the power of the centers. In addition, most of the contractors lined up with their affiliated field center and also served as effective lobbyists in Congress. As a result of the Wallops and Langley meetings, a perception was reinforced that the field centers had become exceedingly powerful.

A second perception related to John Hodge, the director of the Space Station Task Force.[57] Hodge, who opposed the lead center decision, advocated that the program management be located at headquarters (or at least in a neutral center), and was seen by some of the field centers as being partisan about the issue. Johnson had always attracted media attention because of the visibility of its manned programs—Mercury, Gemini, Apollo, and more recently, the shuttle. Personnel at Johnson knew that Washington civil servants generally considered them and the center itself to be overly self-confident, a reflection of their disproportionate media attention. In this climate, Hodge's advocacy of headquarters' management of the program was viewed by some as a bias against Johnson. This perception, whether real or imagined, was to haunt Hodge later in the program.

CHAPTER 5

THE LEAD CENTER DECISION

At the Langley meeting, the institutional leadership of the field centers expressed the belief that the way to structure the management of the space station program was to locate the program management at one of the field centers Johnson Space Center was an overwhelming favorite for the lead center assignment, but James Beggs and Hans Mark did not wish to rush into the decision. The space station program had not yet been announced, and they didn't have to make a final decision on the lead center assignment until December 1983.

Gerry Griffin had won a victory for JSC at the Langley meeting, but he was not complacent about it. He believed that certain key people at headquarters preferred Marshall over Johnson for the lead center. Bill Lucas (at Marshall) and Griffin did not negotiate much prior to the Langley meeting. Part of the reason, according to Griffin, was perhaps that "they felt like they were negotiating from a position of strength."[1] Griffin believed that Marshall had a pipeline to Washington through John Hodge and the Space Station Task Force, and especially through Luther Powell, who was still in Washington at that time. As he weighed his options, Griffin thought that Mark really believed that the lead center should be at Johnson. He did not know Beggs' position on the lead center concept, however.

After the Langley meeting Griffin felt he had a foundation on which to build his case for Johnson. He initiated a number of discussions with Beggs to present his case for Johnson. "I had the Langley experience to kind of build on, and he [Beggs] had listened to that. He didn't have a lot to say, but he just listened to all the different opinions."[2]

Griffin believed that he had the support of many of the players in private industry, such as McDonnell-Douglas and Rockwell, who had developed most of the manned systems since their inception. Of course, it was not to their advantage to push too hard for JSC because if Johnson was not chosen, they would have burned their bridges with Marshall Flight Center. Rockwell and McDonnell-Douglas were pushing to have the lead center at Johnson, as well as IBM and others that had done work with Johnson previously.[3] Meanwhile, the lead center concept was refined through various negotiations. Jerry Craig recalled, "John [Hodge] and I had gone to a field center and presented the basic plan of how the lead center would work and so forth."[4]

Subsequently, "hand delivered" mail began to fly from Griffin to Beggs. The task force, including Robert Freitag, did not have access to information about the negotiations that were taking place between Griffin and Beggs. Freitag never saw their correspondence, nor could he get Culbertson to reveal the contents of the letters.[5]

At this stage the positions of the central players in the decision-making process had already been established. Culbertson preferred the lead center option, and wanted the center to be located at Houston.[6] Hodge, who was pushing for the SE&I function to be located at headquarters during Phase B, had already had his views considered. Mark believed that the technical job of integration should be done at the field centers. In the multicenter arrangement with a number of work packages, integration was really a problem of enlisting the centers' cooperation. This was a political job for which Mark felt headquarters was well suited. "The problem in Houston was one of persuading the other centers to work with Houston as a lead center. And that's the real function of Washington, to do that persuasion. Not

to manage the project out of Washington. And having done that persuasion half a dozen times myself, I know it can be done."[7]

Although the positions of the key individuals were more or less evident, the perception of how the decision was made differed. According to Culbertson, "the decision was essentially reached at a meeting that Beggs, Mark, and Culbertson had. It was there it was decided that the lead center would be at Johnson."[8] Culbertson made a recommendation, and both Beggs and Mark accepted it. Hodge saw different nuances in this decision process. He was aware that the center directors preferred the lead center to headquarters control of the program and that the predominant favorite for the lead center location was Johnson. According to Hodge, Mark "was tickled to death that not only had a decision been reached, but it was the one he wanted."[9]

Most members of the Space Station Task Force did not know about the discussions among Beggs, Mark, and Culbertson.[10] After the Langley meeting, however, they knew that such deliberations had been occurring, but all they had as evidence was the final letter in which Beggs authorized Johnson to be the lead center for the space station program.

Jerry Craig remembered how the letter authorizing the lead center at Houston came about. By then he and Hodge had visited each center.

> [Then] we went over and briefed Jim Beggs. When I got through Beggs said, "Well, what do we do now?" And I said, "Well, we need to write a letter proclaiming JSC the lead center." And he said, "Okay, . . . draft me up a directive naming JSC the lead center and I'll sign it."[11]

So Craig phoned Griffin and told him that Beggs had instructed him to draft a letter naming Johnson as the lead center, and Craig wrote the letter that evening. "And that morning I got a five-page input letter how John [wanted it treated], not a letter. He wanted to put everything in great detail what the lead center was supposed to do."[12]

Craig wondered how Beggs would look upon such a long letter. Disregarding Hodge's suggestions, he wrote a very simple letter and presented it to Beggs. In February 1984, Beggs announced his decision to locate the lead center at Houston, inviting the Johnson Space Center to proceed with the planning of the program office.

Hodge interpreted the lead center decision with caution.[13] As he understood it, the decision to locate the lead center at Houston extended only for the detailed definition period, at which time there would be a review. "I had left with the impression that this decision only stood for Phase B and that we would revisit the whole question of management at the end of Phase B."[14] Such an interpretation was prophetic as it later became evident when General Samuel Phillips reviewed the management of the space station program in May 1986.

The process that led to the lead center decision after the Langley meeting also had an effect at headquarters. The task force members who had advocated the option whereby headquarters controlled the program management had lost out. In addition, they were excluded from the deliberations among Beggs, Mark, and Culbertson. Under Hodge they had existed in an open climate without hierarchical lines of authority, emphasizing open communications and unlimited access to data. The decision process in the case of the lead center was not, however, representative of such an environment. It was more institutional in nature; it followed the protocol and procedures of the agency. The members of the task force were not included in the decision making in this more formal culture, a culture they were not accustomed to during the task force days. The transition back to this more structured environment was not likely to be an easy one.

The Program Manager

Once the lead center concept had been approved, Hodge set up a process for staffing the program office. At the center directors' meeting at Goddard, Hodge presented the outline of his staffing plan.[15] His plan consisted of four main elements: first, all levels of the program would be staffed with the most capable people; second, a search committee composed of a representative from the Office of the Administrator and the center directors would be established to find these people; third, the committee would identify the top twenty positions and screen potential candidates; and fourth, it would report its findings and recommendations to the administrator for his review and approval. Hodge left the center directors' meeting with the impression that the staffing process was acceptable to all present, and that representatives from all centers would be considered for the job of program manager.

The responsibility for coordinating the search for program manager fell to Gerry Griffin, who recommended Aaron Cohen from Johnson for the position.[16] Griffin also received the nomination of James Odom from Marshall. Luther Powell was mentioned, but was not a serious candidate since it was already known that he would lead the project office at Marshall.[17] Andrew Stofan and Noel Hinners also suggested candidates, but it turned out they were not interested in the position.

Culbertson's choice for program manager was also Cohen, whom he considered to be NASA's finest program manager. Hodge did not want the choice to be made without going through the search process that he had advocated.[18] Because Culbertson and Griffin were advocating Cohen without following the selection guidelines that he favored, Hodge decided to take the matter to Beggs, and he let Culbertson know he was going to do it before he did so.[19] In his meeting with Beggs Hodge pointed out that his selection procedures had not been followed in picking the program manager, and, therefore, the agreement that he felt had been made in the center directors' meeting had been undermined.[20]

Mark by then had raised his objections as well. He objected to the consideration of James Odom for program manager as Odom was absolutely essential for the space telescope project, and could not be spared to join the space station program.[21] Mark had other plans for Cohen as well. Mark felt that Cohen, having been a project manager in both the Apollo and the shuttle orbiter projects, needed to broaden his experience to make him a viable candidate for future promotions. Maxime Faget had left Johnson by this time, and Cohen's technological expertise was also needed to replace Faget as head of research and engineering.[22] It was mainly for this reason that Mark objected to Cohen's appointment as program manager.[23]

So the search for program manager began once again, with Mark and Culbertson playing an active role in the selection process. Their prime candidate was Neil Hutchinson from Johnson. Hutchinson was between jobs at the time and fit the younger mold that Beggs wanted in rejuvenating the agency. Hutchinson had worked for Mark in the earlier days of the shuttle as a flight director, so Mark was familiar with his work. Although Hutchinson had never managed a program before, he was a good communicator, was familiar with NASA and the other centers, and had spent some time at headquarters.

By this time the other candidates had for one reason or another fallen by the wayside. Griffin was being pressured to get the program office started, and after receiving the go-ahead from Beggs he offered Hutchinson the position.[24]

Hodge was not happy with this selection either. "I clearly didn't get my point across."[25] Once again his selection process had not been followed. But he decided not to fight it any more, and allowed the appointment to stand without any interference.

There were a lot of mixed feelings about Hutchinson's appointment because many felt that Cohen's previous program experience made him the more qualified of the two candidates. Cohen had very high praise for Neil Hutchinson, even though he was aware of Hutchinson's lack of experience. "I think Neil is a very, very talented person. He is a very good engineer, very talented individual."[26]

The decision to give the job to Hutchinson, however, put Cohen on a track that would later lead to his appointment as center director at Johnson.

> I had a very good job. I mean, there is no better job than head of research and engineering. I would have done the job [Program Manager] if they'd wanted me to. I was not hurt or anything because the job I had was a very good job. Being director of research and engineering after having gone through two programs is not a bad job.[27]

The involvement of Mark and Culbertson in the appointment of Hutchinson was not well known in Washington. There was a perception by some headquarters personnel that they were slowly being removed from decisions regarding the space station program. To them it began to appear that the major decisions were being made by the center directors. According to Hodge, "it removed headquarters one more step from the decision making process."[28]

Hodge's role in the selection process reinforced the perception regarding his biases, real or imagined, against the Johnson Space Center.

> I went through a curious process there ... that got me a bad name down at JSC. ... It was immediately interpreted that I was anti-Aaron, and as a matter of fact, I had nothing against Aaron. ... I thought Aaron was a perfectly fine guy, terrific guy. But I thought the process was so bad that it would destroy the program.[29]

The selection of the program manager sent out a signal that NASA was getting serious about the space station program. The days of the Space Station Task Force and its culture were over. Culbertson assumed command of the space station program, and it moved into another phase, beginning to carry out its affairs. Hodge had encouraged wide participation through his democratic leadership style, but the free-flowing structure of the Space Station Task Force had now served its purpose and Hodge's influence appeared to be waning.[30] With the gearing up of the program office it became apparent that the change in management style, although successful in the task force, was not to become a NASA standard.

Even before Hutchinson had been selected as the program manager, Griffin had talked to **John Aaron** about the deputy's job.[31] Once Hutchinson's appointment was announced, Griffin brought Aaron to Culbertson's attention. Culbertson had earlier gained a deep respect for Aaron and enthusiastically supported Griffin's recommendation. Beggs endorsed their choice and Aaron was appointed deputy program manager. Although both the key individuals that would head up the space station program fit in well with Beggs' notion of rejuvenating the space agency, neither had program experience.

The lead center decision, the changing role of Culbertson, and the appointment of the program manager and deputy program manager signaled the arrival of the space station program. By the time these announcements had been made, President Ronald Reagan had made his speech approving the space station program. One major decision remained: how should the space station program be divided among the various field centers?

CHAPTER 6

WORK PACKAGE SPLITS: ROUND ONE

The technological guidelines established by the Space Station Task Force in 1982 suggested that there would be a number of field centers working on the program. Because their expertise lay primarily in manned programs, both Johnson and Marshall had been deeply involved in the task force and would undoubtedly be involved as the program was now formed. Because the scientific community was then considered to be the primary user of the space station, Goddard, the science center, would need to be involved. The Jet Propulsion Laboratory (JPL) had also worked with the scientific community, so their involvement was also a probability. The emphasis on technology development implied participation by Langley, Ames, and Lewis, NASA's research centers. And, finally, since operations responsibility lay primarily at the Kennedy Space Center, Kennedy would play an integral role in the program once the station was ready to be launched.

The field centers had much to gain from the approval of the program. The directors and their respective centers would gain visibility by participating in NASA's next major initiative. Perhaps more important than the visibility, approval of the program meant there would be new resources available to participating units. In an austere economy, additional monies were essential to maintain the institutional base and employment at the local level. Moreover, for the center directors, their own visibility and status in their regions would be enhanced.

The program had not been approved in early 1982, however, so it was premature to consider distribution of resources. Instead, the center directors had to focus their attention on their ongoing operations. This may have been a blessing to John Hodge, director of the Space Station Task Force. Rivalry among the centers receded, and Hodge could get the members of the Space Station Task Force, drawn from various centers in addition to headquarters, to concentrate on building the constituency and determining the specific details of the upcoming program.

In 1983, as NASA became more confident of winning approval of the program, the issue of resource allocation received more serious attention. Work packages—i.e., portions of space station work each center would perform—were negotiated over an extended period. These negotiations were complex, intense, and lengthy, and they often appeared chaotic to an outsider, and even illogical to some within the agency.

In February 1983, Culbertson and the task force held a competition for allocating the advanced technology development "test beds." The test beds were not part of the work package decisions, but had a significant impact on the expectations of work package assignments and the negotiations for those assignments.

Test Bed Competition

Even in the early days of the Space Station Task Force, the members considered advanced technology development to be a part of the space station program. This consideration was a reflection of the Space Station Technology Steering Committee, which had stated that it was essential to continue technology development for the evolutionary and growth aspects of the program.[1]

As visualized by the task force, there were several objectives of the advanced development activities. The first objective was to develop "test bed" capabilities along major disciplinary lines and located at various field centers so that technology alternatives and configurations could be tested and evaluated. Second, any promising new technology arising from the test beds could then be transferred to the space station development program. And, finally, based on those new technologies, qualified industry subcontractors could be identified for later consideration during the design and development of the station.[2]

Historically, NASA and OAST had adopted a way of describing progressively increasing levels of maturity in technology development. The process was divided into traditional categories of research, generic technology, focused and applied technology, and advanced development. In the past, OAST had funded technology development through the generic base. Afterwards, major developmental programs carried focused technologies into the advanced development stage. The space station program would follow this pattern.

The thrust of the advanced development program was to develop generic "test bed capabilities" where new technologies and approaches could be tested for performance and the estimated risk in terms of cost and schedule. Testing allowed new technologies to be integrated into the later phases of the space station program. This approach would provide sufficient flexibility to accommodate diverse new technologies throughout the life of the program. The task force also recognized the need for selected flight demonstrations in space as well as on the ground.[3]

The advanced technology test beds were funded primarily through OAST. OAST funded the technology that it would normally have supported, and managed some of the space station funds that were focused on specific problems related to the technology of the space station. It was jointly managed as a single integrated program, but part of the money came from OAST and was generalized in its application, and the other part was space station money, and was more specific in its application.[4]

Why should advanced development test beds be developed so early, especially since the technology program would not have an influence on the initial space station design and development stage? Culbertson, who oversaw the space station activities, explained the reasons for the early allocation of test beds, as he saw them:

> [There were] two reasons. One was that we felt that the test beds provided an opportunity to get the technology program going before the contractor selections had been made [before Phase B RFPs], and provided a focal point for the development of individual components, which would ultimately fit in systems. Second, and more importantly, by getting the test beds and putting the responsibility for the test beds in the development centers rather than the research centers, but still leaving the research centers with a broad responsibility for many of the components that would go into the test beds, it helped forge a closer relationship between the research centers and the development centers. In other words, the idea was that if Marshall or Johnson had the responsibility for the overall communications system, the test beds encouraged Langley, Ames, or Lewis, or any other center with interest in a particular part of the system to manage its early technology up to the breadboard level or to the concept level, and to bring their components to the test bed at the appropriate development center. It provided a good working relationship, then, between those research and development centers.[5]

The center directors were very interested in the test bed concept, of course, because it meant additional technical responsibility for their centers.

Culbertson and the task force decided to hold a competition for the assignment of the test beds, with the centers submitting proposals as if they were contractors making bids. The field centers were encouraged to team up to bid on the proposals. Culbertson wanted the centers to depend on each other, and the built-in competition was a way of doing this.[6] The center proposals were finally submitted in February of 1983, about six months before the Wallops and Langley meetings. Culbertson, however, did not announce his decision until February 29, 1984, after President Reagan's State of the Union Message directing NASA to build a permanently manned space station.

The test bed assignments carried with them dollars which were minuscule related to the overall space station program. This allowed Culbertson to make up his mind without an elaborate set of criteria, focusing on the technical capabilities and possible long-term roles of the field centers who competed. The rationale for his evaluation was relatively straightforward, even though he was assisted by an independent committee. Johnson, with its longstanding emphasis on manned aspects of NASA's programs and the proximity of the astronauts, won the lead assignment for the advanced development programs in data management, environmental control and life support, and thermal management. Marshall, noted for its structural engineering and propulsion systems capabilities, won the assignment for altitude control and stabilization studies, the ancillary propulsion system, and the space operations mechanisms.[7] There was, initially, no lead center for the advanced development program on electric power.[8] This was later assigned to Lewis when, due in part to Stofan's efforts, Lewis was given a major development role in the space station program.

At this stage there was no way that Culbertson or the members of the task force could grasp the enormity of the work package problem. As a result, problems arose. The centers appeared to believe that the test beds (and the subsequent work packages) would be housed permanently in their respective locations. Center personnel began to view the test beds as their own, leading to "turf battles." Aaron Cohen, then the director of research and engineering at Johnson, commented, "I thought it [test bed competition] had some merits to it. I thought that was a very fair way to do it. ... [But] I think it tended to lead to some turf battles."[9] And while the test bed competition was in progress, the center directors launched a number of initiatives to determine how the space station program would ultimately be divided among the centers.

Initial Field Center Considerations

The idea of the work packages emerged initially from the meetings that Hodge and Culbertson had with several center directors. It was recognized early in the program that space station program would be a large one and, therefore, more than one center—at least Marshall and Johnson—would be involved.[10]

During the advanced development test bed competition, the Space Station Task Force, under the direction of Hodge, focused on the missions that the station needed to accomplish. Meanwhile, although the configuration had not been decided, the center directors were deliberating internally for their role in the program. And it was only at the beginning of March 1983, as Luther Powell and his group began work on concept development, that the station's cost estimates and the configuration received attention.

The demands of the station's electrical power system that Luther Powell's assessment had provided surprised many members of the task force. Electrical power constituted a large component of the space station program, and Andrew Stofan wanted the power system for Lewis. Lewis' strength lay in

propulsion systems, and adding a developmental capability would enhance its already renowned technological and research capabilities. Because of Marshall's expertise in power systems dating back to the Von Braun days of the 1950s, Marshall was Lewis' competition for the power system on the space station.

Stofan lobbied both James Beggs and Hans Mark for the power system.[11] He initially faced resistance from both, especially Mark. The crucial question here was whether Lewis was to be involved at all, not if Lewis would be given the power system assignment. In the end Stofan's persistence paid off. Both Beggs and Mark decided that not only would Lewis be involved, but that Lewis would have the power modules.[12] It was clear that Stofan had made his case very clearly known, both within NASA and among Ohio's Congressional delegation, and there was a perception that the strong congressional contingent from Ohio had a major influence on this decision, but Mark denied it. "The strategic plan for Lewis and giving Lewis a role in the power area of the space station was terribly important for the future development of that center. And working the Ohio delegation was a minor part of the contract."[13]

The inclusion of Lewis as a work package center concerned Culbertson. Johnson and Marshall were working the manned elements and Goddard the unmanned elements. The inclusion of a fourth center increased the management complexity. As Culbertson explained, "Management complexity increases as the square of the number of centers you've got involved. With 3 there was a number 9 and with 4 there was a number 16, so in my mind we almost doubled the complexity."[14] Culbertson recognized, however, that Lewis had a lot of power experience in research and technology, and had done some demonstration projects on space power systems development. "So, if we were going to add a center for the space power system, Lewis was the proper choice. Aside from the increase in management complexity, it was logical that we assign the power system at Lewis."[15]

Goddard's involvement in the space station program, on the other hand, had been advocated by Hodge and the task force. In Hodge's estimation, Goddard had a better relationship with and understanding of the user community than did Johnson or Marshall.[16] "So we brought Goddard into it to make sure that the users would be adequately represented and would recognize that we were committed to the idea of making it useful to scientists. We felt that Goddard could do that very well."[17] The role of Goddard, therefore, was to have two important aspects. First, to manage the development of some of the hardware, and second, to be the user advocate in the program organization.

There was some reluctance at Goddard, however, to be so actively involved with the space station. At the start of the shuttle project, scientists, including those at Goddard, had participated in establishing shuttle requirements. After that had been accomplished, however, the user community was no longer included in the shuttle's development, and many at Goddard felt left out of the shuttle project. Noel Hinners, center director at Goddard, had to overcome the reluctance of Goddard management. He thought Goddard should be involved and spoke very positively about Goddard's participation. He, too, felt that Goddard could bring a user perspective to the space station program, as well as benefitting from the visibility that would come from working on a major NASA program.[18]

It could be predicted as far back as 1983 that once the space station became operational, Kennedy Space Center would have a relatively large role to play. Because the station would insure a permanent human presence in space, Kennedy would be involved in maintaining and servicing it (not merely the payload) in addition to the basic requirements for launching the station, once it became operational.

Langley Research Center had been an early candidate for the lead center, but Hodge and Culbertson were unsuccessful in their attempts to persuade Don Hearth to locate Level B there.[19]

Instead, Hearth reserved for Langley technology development during the evolutionary stages of the space station. In doing so, he insured a future involvement and influence as the program proceeded, and also reduced the potential loss of center personnel to other centers.

Marshall and Johnson were, of course, major contenders for parts of the development of the station. Since the space station was a major program, and even the initial operating capability contemplated by the Space Station Task Force was immense, there was no doubt that development work would have to be split between Marshall and Johnson and could not be located at just one of the centers. Although the two centers had somewhat different areas of expertise, the distribution of work between them was still going to be a problem.

Ames Research Center was a different story. Mark had been Ames' center director from 1969 until 1977 when he left NASA and joined the Department of the Air Force. When he assumed the directorship in 1969, there were proposals to shut Ames down. One of Mark's first acts as director was to establish a Strategy and Tactics Committee, consisting of rank and file employees as well as managers, to work out Ames' view of its mission. Out of these activities emerged a mission statement for Ames which indicated that the center would emphasize certain areas: computational fluid mechanics, V/TOL, flight simulation, airborne sciences, and life sciences.[20] It was unlikely that Mark would allow a redefinition of Ames' mission at this point.

In the summer of 1983, in preparation for the Wallops and Langley gatherings, Mark asked the center directors if they had the technical resources needed to build a space station.[21] As we have seen, the key to program and project implementation was the institutional support of the center directors. This support would be vital once the program had been approved. The center directors had responded that they needed to know more about the station's capabilities and technical characteristics, dimensions on which the Space Station Task Force had been working. The Space Station Management Colloquium held at Langley on September 22, 1983, "seemed to be the place to learn more."[22] It was too early to talk about work packages then.

The Langley meeting did not specifically address the issue of work packages. The discussions revolved primarily around whether the centers had the in-house capability to perform the systems engineering and integration function, if they had enough support personnel, and which way to perform the SE&I: should it be done at headquarters or at the field centers? Although the center directors did not have a clear understanding of the extent of SE&I support necessary for the space station program, the overwhelming conclusion was that NASA could do SE&I in-house without the aid of a support contractor.

Technological Considerations

As the Concept Development Group (CDG), under Luther Powell, deliberated the space station configuration, the issue of work packages and the technological interfaces among the work packages received serious attention.

The space station program had been advocated as an agency-wide initiative, incorporating both unmanned and manned elements. The manned elements insured a permanent human presence in space, whereas the unmanned elements really referred to the platforms for conducting scientific research. These platforms were only loosely related to the manned elements of the space station, since platforms could be designed and deployed in space without any connection to the manned elements.

By then, however, the Space Station Task Force had begun to advocate the notion of commonality in the station. The $8 billion figure for the space station implied that the cost would have to be tightly controlled in the program. To contain costs, Hodge and Powell advanced the idea that the manufacture of the various components of the station be standardized. Insofar as the platforms were concerned, their only link to the rest of the station was the need for commonality; platforms should, to the extent possible, employ elements that were developed for the manned station.

The interfaces between the platforms and the rest of the space station, arising from commonality, were not heavily influenced by work package decisions; therefore, the CDG realized that the major question regarding the work packages was the distribution of work between Marshall and Johnson. An early attempt to tackle the question of work packages was made by W. Ray Hook, a member of the CDG. "I was the guy that first made an attempt to divide the work. And very unsuccessfully, I might add."[23]

Hook looked at the work package problem pretty much from a technical capability standpoint. The crews live and are part of Johnson, and politically that was not likely to change. The things that the crews would be intimately involved with—the habitation modules, for example—he felt also ought to be handled at Johnson. By and large he felt the rest of the spacecraft could be built at Marshall. So Hook's proposal was to "divide the thing in half, give yourself two main prime contractors, split off these pieces and have them managed by the other centers, and have as many work packages as you'd like, but concentrated into the two manned space centers, Marshall and Johnson."[24]

Technological requirements drove the management process in these early days. It was felt that the technology required by the station necessitated two work packages with clear interfaces, just as had been done with the shuttle. Marshall and Johnson would each spearhead one of these work packages. Even then it was not obvious where the split would be made.

But a decision could not be made purely on technical considerations. There was the political situation to be concerned about, as well as the institutional relationships between the centers. As it happened, when Hook made his presentation to Culbertson, the recommendation of dual work packages with Marshall and Johnson each having a major share was turned down.[25]

Following the Langley meeting, the CDG began to pay closer attention to defining the initial capability of the space station.[26] Once the CDG had detailed the desired initial capability of the station, Culbertson asked Bryant Cramer to assemble a working group to develop a concept for how to logically approach the entire work package structure.[27]

Cramer's group, with input from industry and field centers, analyzed fifteen work package options. The particular criteria that the working group applied were interface complexity, configuration sensitivity, and programmatic constraints. With the help of a Center Technical Advisory Group set up to review the options and evaluation process, Cramer's people created a "straw man" cut as to what the work package distribution might be.[28]

The working group reached an analytical solution that was close to what NASA finally ended up with. The CDG had provided a general configuration and then Cramer's group established where the interfaces were from system to system and then counted the number of interfaces. They felt that one criterion for the decision should be to minimize the number of technical interfaces between work packages. And so "they massaged this in every possible way they could find that minimum."[29]

Preliminary Negotiations with Field Centers

A series of preliminary negotiations with field center directors was initiated by Culbertson, who had the advantage of Cramer's analysis. Culbertson conferred with all the directors individually about the work package analyses conducted at headquarters. He wanted a general agreement over the concepts that had been put forth by Cramer's working group.[30]

However, Bill Lucas, the director of the Marshall Space Flight Center, did not concur with the work package splits recommended by Cramer's group. Lucas objected to those work package splits because Marshall's job, in that version, was seen to be an assistant role to Johnson.[31]

In addition to minimizing technological interfaces and making the best use of the established capabilities of the two centers, Culbertson worked to form work packages in which Johnson's and Marshall's responsibilities would be of comparable magnitude. "I did not want one lots bigger than the other."[32] However, having given the lead center responsibility to Johnson, Culbertson did not want to arrange the work packages in such a way that Marshall would have a major integrating role, because to do so would leave them competing for the integration. This question hinged on two major elements of the station: allocation of overall structure and geometric arrangement (which he called the architecture) of the entire space station versus the inhabited modules. According to Culbertson's thinking, the responsibility for the overall structure and architecture should lie with the lead center. If the lead center did not have that responsibility, it would not have the integrating role, and thus would be subordinate to the work package that had the responsibility for the structures. Culbertson did not want this to happen.[33]

Distribution of work arrangements in an equitable fashion between Marshall and Johnson without a major integrating role for Marshall was complicated by the advanced development test bed allocations already made. When Culbertson had made the test bed assignments, the complete work package structure had not yet been determined. The allocation of the test beds, however, had reinforced expectations that the work package assignments would likely follow the centers' relative expertise. As a result, aspects of the habitation module were left at Johnson and facets of the structural parts of the test bed assignment were located at Marshall. As the work packages were finalized, however, it became clear that the structural assignment to Marshall would create problems because the structure was the crux of the integrating job in the station.

By then Marshall had lost the battle for the lead center assignment to Johnson, but the work package issue was another matter. Historically, the capabilities associated with the habitability module lay at Johnson. That's how many saw it.[34] Marshall personnel, however, believed that they also had expertise in living quarters, having built the quarters for Skylab, which were much larger than those for the shuttle, which were built by Johnson. Therefore, Marshall felt they had built the only real living quarters up to that time.[35] Furthermore, Marshall had had a major role in the oversight of ESA's development of Spacelab.

The structural expertise for building the space station lay at Marshall, at least in the perception of that center, and this had been reinforced by the earlier allocation of the test bed facilities.[36] So, when Culbertson suggested that the structural aspects of the space station program should lie with the lead center, that is, Johnson Space Center, Bill Lucas was naturally resistant. He had already lost the lead center role, and now it seemed he would also lose one of the areas of expertise for which Marshall had a good reputation.

Because Culbertson received strong resistance from Lucas, he decided to bring this topic to a center directors' meeting in Washington in March of 1984. By this time Neil Hutchinson had been selected program manager for the space station program, and he attended the Houston meeting. The center directors did not resolve the work package issue at that meeting. According to Culbertson's recollection, "we worked for most of the day to see if I could get agreement and couldn't."[37]

Culbertson then decided that if he stepped back and let the two centers work together on the split without intervention from Washington, a solution might be forthcoming. He told Griffin, "You've got the Level 2 responsibility. See if you and Bill can devise an amicable solution to the split in responsibilities between yourselves."[38] But the tormenting work package dilemma was not going to be settled that easily.

Work Package Negotiations Between Marshall and Johnson (April-July 1984)

As Griffin assumed the responsibility for negotiating the work packages among the field centers, he was keenly aware of four factors that would make his task both sensitive and complicated. First, and perhaps most importantly, Griffin had the role of the lead center director in the space station program. There was an agency-wide perception that in the lead center arrangement the director of the lead center would be directing the work of other centers. Although all the field centers were considered to be equals, the lead center assignment elevated Griffin's status, and that of his center, above the others. Griffin was aware that was going to complicate his task of negotiating work packages.[39]

Second, when he was assigned the responsibility for work package negotiations, Griffin did not have the benefit of a clearly delineated configuration for the space station.[40] The reference configuration would be discussed and selected later during the "skunk works,"[41] but as of March 1984, the skunk works had not yet begun. The work package negotiations that Griffin headed ran concurrently with the skunk works. The input from the skunk works would be important, but the negotiations were ambiguous because the configuration details were still unclear.

Third, Griffin was concerned about the reaction of Johnson personnel during the negotiations. There was a widespread perception in the agency that the center would exert a strong influence on its director. Griffin knew that he had to appease his own institution, especially if the negotiations went counter to their expectations.

Fourth, Griffin was aware that some of his earlier positions with respect to the work packages had been undermined by negotiations that had taken place at headquarters when Marshall and Lewis had competed for the power system. As he recalled, "I do remember literally being lobbied by both Bill and Andy that they ought to do the power system. And they were more or less communicating with me to support their position."[42] Coming from a development center himself, Griffin wanted Marshall to have the power system. He felt that getting another research center into development would weaken the agency overall. "I really thought that the Lewis Research Center ought to remain a research center. So I really supported Marshall, quietly."[43] However, Griffin's position—that the power system should be allocated to Marshall—was undermined when Lewis won its bid for the power system.[44]

These four factors influenced Griffin as he worked with the other NASA centers to define the work packages. At that point he began what he called "shuttle diplomacy." "I was flying around all over the place. I'd go to Goddard, I'd go Lewis, I'd go to headquarters, I'd go to Marshall."[45] The negotiations

between Marshall and Johnson were the most sensitive. It was generally thought that Marshall and Johnson could cooperatively run the program, like the Apollo program, in which clean interfaces were possible. In the case of the space station, the question was how to split up the program between the two centers.[46]

Although Griffin negotiated with Lucas and other center directors, two major meetings occurred between representatives from Marshall and Johnson. The first meeting took place in April 1984 in Huntsville, Alabama. In this meeting, the Marshall and Johnson teams considered two major alternatives on the principle that they would distribute the dollars equally. The first alternative located the SE&I function and the habitation modules at Johnson, and placed the resource, lab, and logistic modules at Marshall. The second alternative was to have the resource module and SE&I at Marshall, and the rest at Johnson. It made sense for both of the development centers to be roughly equal in terms of their next piece of the initiative.[47]

This first meeting was inconclusive. As Aaron Cohen explained, "Whenever you tried to break it down in a neat way, it didn't come out, you just couldn't make a very neat solution like you could in Apollo or shuttle. So, although those discussions weren't heated, the discussions were not very conclusive either."[48]

Following the first meeting informal conversations took place between Griffin and Lucas. Perceptions began to diverge at this point. Although Marshall executives knew they could do the SE&I job, Griffin had decided to do it at Johnson. Because the program management office, Level B, was already located at Houston, it made sense for Johnson to perform the SE&I function.[49]

However, as Marshall personnel saw it, the SE&I job and the habitation module were not enough for Johnson to take on. Some even felt that Griffin could not convince his institution to go along with this alternative. The reason, perhaps, was that SE&I did not carry with it hardware responsibility.[50] This meant that during the later phases of the program (beyond Phase B), Marshall would have a larger hardware development role to play than Johnson. Unable to resolve the issue, the Johnson and Marshall teams met a second time, also unsuccessfully.

Although Culbertson had directed Griffin to come up with a work package, he did refrain from participating in the deliberations between Marshall and Johnson. He received briefings from Griffin to keep him abreast of developments. As the negotiations between Marshall and Johnson continued, Culbertson asked Hearth, center director at Langley, to arbitrate one of the sessions between Marshall and Johnson.[51] Culbertson selected Hearth for this role for a number of reasons. Culbertson believed that Hearth had little personal relationship with either one of the centers, and was unlike Dick Smith, for example, who had been a deputy director at Marshall and had worked with Griffin. Second, Hearth did not appear to have a vested interest in the negotiations since Langley's role was already established. Langley was a research and technology center and would support all the centers. Hearth, therefore, was not perceived as a threat either to Marshall or Johnson. And, finally, Hearth had chaired the meeting at Langley at which the lead center responsibility and the work package concept had been developed. So, Culbertson told Hearth, "you dreamed this up for me, now help me solve it."[52]

The belief in Hearth's ability to be unemotional in tackling the issue was shared by Noel Hinners. "He's very good at being a facilitator, getting decisions made, getting the arguments and discussion out on the table, getting at the facts, getting the emotion out of the way, trying to establish what are the facts."[53] However, Hearth could not negotiate an agreement. Bob Marshall, at Marshall Space Flight Center, felt that the arbitrator sent back what they had started with, and did not really arbitrate.[54]

Finally, on June 5, 1984, Griffin made a formal report to Culbertson regarding his assignment, and recommended a division of the space station work for the Level C centers. He noted that some guidelines that had evolved from Level A had influenced his recommendations. These included, "the location of the power system responsibility at Lewis and a significant role at Goddard in customer utilization."[55] Griffin reported that with one significant exception, most of the centers were generally comfortable with the work split that he proposed. The exception was Marshall. In a letter to Culbertson a month later Griffin shed some light on this inability to come to an agreement with Marshall and urged Culbertson to finalize the work package split.

> Our areas of disagreement are significant and, I believe, are based on honest differences of opinion as to how the program should be structured. Over the last two months, particularly as a result of the skunk works activities, our overall understanding of the space station program has grown and evolved considerably. The discussions with the MSC [Marshall] people have been carried on in parallel during this period of program evolution. Hence, our discussions have lacked a crispness that I believe is not unexpected, considering the rather unique way we set out to initiate the space station program. I believe the situation has added considerable difficulty in coming to a better understanding between our two centers.[56]

Once Culbertson felt Griffin could not get an agreement, he decided to approach Beggs directly with a recommendation. "I sat down with Mr. Beggs and said, 'This is my recommendation. The system would not come to any consensus.' They were going to have to be told, and I told him this was the arrangement that I recommended."[57] Beggs approved and Culbertson's recommendations became the work package allocations for Phase B.

Culbertson's solution did not completely match the capabilities of the centers, and in some instances the earlier decisions he had made with respect to the advanced development test beds came back to haunt him. For Culbertson, however, his work package splits hinged on two factors. First, to the extent possible, he wanted to maximize the match between the work package and the capabilities of the center. Second, he assigned the work package to Johnson that would be in line with its lead center responsibility, even though, to some extent, it varied from Johnson's capabilities.

According to Culbertson's decision, Marshall would build and design modules with everything that would remain common to the habitation module and the laboratory. And, since they were all to be enclosed (and lived in or worked in by the astronauts), it was logical that one of the systems that should be relatively common from module to module was the environmental control life support system (ECLSS). This meant that ECLSS could not be assigned to Johnson, because it would have been very difficult for Johnson to design all the systems and components and figure out how to test them and install them into a module that was being designed by a contractor who was working for Marshall.[58] Although Johnson was the kingpin in manned space activities, ECLSS went to Marshall. At the same time, the stabilization control system involved the dynamics of the whole structure, and that went to Johnson. "If that responsibility went to Marshall, I'd have the same kind of a problem as I was having in the other one" [the module]. So, according to Culbertson, "If each one of them—Marshall and Johnson—recognized that it was going to have to lean on some of the other's technical strength ... that if each one of them was dependent on the other for a piece of its responsibility, maybe they would figure out they'd have to work together."[59] Why not, then, redistribute the assignment in such a way as to be more completely compatible with the centers' own strengths? Culbertson was against it for the simple reason that Johnson had the lead center responsibility, and to a degree the primary structure was a

major integrating tool.[60] Although he fully recognized that his solution was a compromise, he felt it was an acceptable compromise and was better than any of the others that had been considered.

Culbertson's final work package division included two lab modules, one at Marshall and another at Goddard, even though he believed that NASA would end up with only one laboratory module. However, he had his reasons for the definition of two lab modules. Since the laboratory module was a new idea, he had two centers, each leading their two contractors, working on the lab module "so we could get the best thoughts the country could put together."[61]

As Culbertson saw it, Hodge and the task force assisted him in sorting out the work packages before the Phase B RFPs went out. According to Hodge, however, "Phil worked that personally with Gerry Griffin and John Aaron, and I didn't get involved in that. I was fairly sure the people down there didn't want me involved in it." Hodge interpreted the reasoning behind the work package decisions that were ultimately made:

> The way it turned out, the rationale that was used was, Marshall had more experience in pressurized manned things with the Skylab and Spacelab, so they took all the pressurized modules. Johnson wanted to take the rest of it. Because of the architectural control, overall configuration control became Johnson's, which was what I wanted.[62]

After all this was done, Culbertson noted, "some changes of the work package assignments may be necessary upon the completion of the Phase B definition effort, because only then will we really understand the configuration we've been working so hard to split into pieces."[63] So changes were still a possibility as the study progressed.

Culbertson's work package decisions differed significantly from Griffin's recommendation. Whereas the relative expertise of the different centers was the primary driving force behind Griffin's recommendation, Culbertson focused on an additional factor. He argued that the structure of the space station formed an important integrating mechanism for the program, and, therefore, should be assigned to Johnson Space Center. As a result, the module was allocated to Marshall, although expertise for habitation modules seemed to be at Johnson. In a similar sense, although Marshall's expertise seemed to be in structures, the structural elements of the space station were allocated to Johnson. Thus, the need for locating the structural parts of the space station at the lead center, where the program management function was performed, lead to a work package distribution that did not match the expertise of Marshall and Johnson.

Although Culbertson's decision differed from Griffin's primarily with respect to the hardware elements of the space station, over time another difference appeared. Based on Goddard's past experience with the users, both Culbertson and Griffin felt it would be desirable to have the customer utilization function located at Goddard. This turned out not to be the case, however. Noel Hinners, center director at Goddard, argued that the customer utilization function involved more advocacy than research; therefore, the ideal location for that function was with the program management. Hence, he stressed that the customer utilization function should be located at Houston.[64] As the Phase B studies started, the customer utilization function was performed by headquarters and the Level B office at Houston.

Culbertson's initial work package decisions were influenced by a number of factors. The first, of course, was Beggs' guideline that the space station program be an agency-wide project. Influenced by congressional delegations from various districts, the number of work packages increased to four. Although there was congressional query about hardware development responsibility at Kennedy, it was

effectively thwarted because the Kennedy Space Center was to have a major role during the operations phase of the space station program.

Second, during the period when Culbertson made his decision, the configuration of the space station had not matured. The CDG had defined an initial operating capability of the space station program, and the skunk works was refining a reference configuration, the "power tower." However, even then, Culbertson, Griffin, and Hutchinson knew that the reference configuration would change during Phase B when more informed studies would be conducted by the work package centers in conjunction with their contractors. Several questions still needed to be answered. How would international participation influence the configuration and the work package allocation among various international participants? How should the space station be assembled? How should it be verified? What were the implications of operations on the configuration of the station? These questions could not be addressed in the short time frame in which the CDG and the skunk works operated. Only during the Phase B studies could precise answers be provided.

As a result of the uncertainty created by such unanswered questions, the work package negotiations appeared chaotic to onlookers, and even to many participants in the larger NASA community. To a large extent, the appearance of chaos was inevitable, given the circumstances under which the decision was made. Perhaps such chaos could have been avoided if NASA officials had postponed the work package decision until after the Phase B studies were conducted. However, the congressional pressure and the industrial contractors' influence were important in arriving at an early work package decision and Culbertson felt that the Phase B work would be impossible to control if the center responsibilities had not been at least tentatively determined first. Since such pressures were evident to many members of the NASA community, the work package decisions that Culbertson orchestrated were often viewed as political engineering, rather than anchored in solid program rationale.

Culbertson's work package decisions were a major factor influencing the evolution of the Phase B studies. As we have seen, the uncertainty in the overall configuration made it impossible for them to be cast in concrete. This also led to overlap among the work packages, which meant that the four field centers and their contractors working on space station definition would have considerable room to attempt to influence the definition in ways which would enhance their own positions. Since resources were spread around, these redundancies and overlaps set the stage for a definition period in which intercenter and contractor rivalry would influence how the Phase B studies, and therefore the space station configuration, evolved.

PART III

THE EXPERIMENT COMES TO LIFE

CHAPTER 7

SKUNK WORKS

With two crucial decisions—the location of Level B and the advanced development test beds—behind them, and another major set of decisions—the work package splits—well under way, NASA executives focused on managing the space station detailed definition (Phase B). By now the management activity had moved from Washington, D.C., to Johnson Space Center in Houston.

Space Station Management Workshop

During January and February of 1984, Johnson developed a range of Level B organizational issues and options in preparation for the Level B lead center assignment.[1] Following Johnson's designation as the lead center on February 15, 1984, James Beggs directed Gerry Griffin to develop a detailed functional plan by March 15, 1984. Since space station was an agency-wide program, it was necessary to discuss the issues not only from Johnson's perspective, but from the viewpoint of the other centers who were to be involved as well. The major goal of the Space Station Management Workshop, held at the Lunar Planetary Institute in Houston in August 1983, was to develop a refined plan. It was essential that senior management from each NASA center participate in the workshop.

Robert Goetz, the deputy center director at Johnson, chaired the workshop.[2] It was attended by the deputy directors of the major centers and personnel from centers who were likely to be involved with the Level C activity. Robert Freitag represented NASA headquarters. A total of twenty people participated. Louis DeAngelis, who conducted training seminars, was the facilitator.

Goetz made the introductory remarks and presented the range of uncertainties, guidelines, issues, and organizational options that Johnson had prepared. This was the starting point for developing an agency position on the Level B functional plan, and Gerry Griffin's "barbed wire diagram" (figure 2) received much initial attention. The discussion of Griffin's diagram brought out the complexity of the program. Customer and operations interface, in-house systems engineering and integration (SE&I), and involvement of the key centers complicated the task of management.

After introductory discussions, the workshop broke into four working groups. Each group looked at a number of management issues, including the functions and alternatives for Level B, the station's configuration, and the related SE&I tasks. Each team worked up its ideas on the topic at hand and then the larger group assembled to review the teams' findings.[3]

The three-day workshop generated a lot of heated discussion, but it also brought together all of the center people with a camaraderie that had not been present before. Participants began to look past the needs of their own centers to the needs of NASA as a whole. As one participant put it, "I've got to worry about NASA because my center can't float if NASA sinks."[4]

Although the workshop considered various issues, there were certain "knowns" for the program.[5] First, the initial deployment for the $8 billion station would start in the early 1990s. Second, there would likely be international involvement, but the details of that international participation were not clear. Third, all centers would be involved. Fourth, a Phase B definition period would be initiated in FY85, lasting for two years. Fifth, six advanced development test bed teams had already been assigned. And finally, the lead center for Level B program management, assigned to Johnson, would have at least five

major responsibilities: SE&I; business management; operations integration; customer integration; and support of Level A.

During those three days the workshop considered several structural options for Level B, although it was assumed that the Level B organization would evolve with the program and the functional structure would accommodate major international involvement at the hardware development and customer levels.[6] The options ranged from a matrix type organizational approach to a more self-contained Level B organization. In a fully matrixed situation, Level B would rely on the Johnson institution for manpower and technical support. In a self-contained option, Level B would staff its own organization with people from either Johnson or the other centers. In the shuttle project the lead center worked more in the matrix fashion than as a self-contained entity,[7] and within the Johnson center itself at that time there seemed to be a strong feeling that Level B in the space station program should be matrixed as well.

The Space Station Management Workshop also advanced technical integration panels as coordination mechanisms for Level B and a carryover from the shuttle orbiter project. There were two types of technical panels. First, disciplinary panels cut across the work packages. "We had a power panel, life support panel, communications panel, data processing panel, and so forth."[8] The second type of panels cross-cut and leveraged the individual discipline panels, tying together to integrate and distribute their work. An example is the configuration and performance panel.[9]

The workshop participants also discussed the interfaces that had to be established between Levels B and A, as well as between the Level B and Level C organizations. They assumed that Level B could be organized without knowing the specific Level A organization, which did not yet exist.[10] Clearly, a customer utilization office at headquarters would have to interface with the customer integration office at Level B. Also, the mission requirements working group function would have to provide an interface between the two levels. In addition, the workshop promoted the idea of technical panels to integrate the Level C offices and the program requirements. This was not new in NASA, but a carryover from the previous lead center assignment in the shuttle project.

Although the workshop dealt with several procurement strategy options, the participants could not decide which strategy would be best for the program. The options ranged from one systemic work package for the station complex to total system contracts separated into four identifiable tasks within the contract. The workshop outlined an approach: a procurement development group would be established in the skunk works to develop a strategy before the RFP was released. This group would make maximum use of the existing Space Station Task Force and its CDG, and it would include a wide participation from all the Level C centers.[11]

Inevitably there were discussions about the configuration of the station. Johnson preferred one configuration, called the delta, but it seemed to have some serious limitations. After some spirited debates it was decided to defer to the skunk works to produce a reference configuration.

SE&I also received its share of attention. The workshop developed several assumptions regarding the performance of SE&I. First, as stressed in the administrator's office, there would be no system or integration contractor. Second, the Level B SE&I might be partitioned to be performed at multiple centers, and all centers would support in-house SE&I. Third, support contractors could be used for in-house SE&I. The customer and operation integration functions had to participate in this function. Estimates were developed regarding the manpower required. They showed that perhaps the technical personnel required for the systems engineering and integration function would be Level B's most

important human resource. Of course, all centers had to provide key Level B personnel, that is, personnel for the SE&I function.[12]

The workshop's most important decision was to proceed with the skunk works, a concept that had originated in the work of Clarence Kelly Johnson, an aircraft designer at Lockheed.[13] It was decided that the skunk works would be located at Johnson Space Center no later than April 1984, and it would have three objectives: 1) to define the station's functional requirements; 2) to develop a total procurement plan; and 3) to create a Level B program plan. The workshop recommended that the skunk works fold into Level B. The skunk works would perform evaluation and trade studies to define the station's functional requirements and its reference configuration. Because Johnson had the lead center assignment, the skunk works would be located in Houston, although all centers would be involved. The CDG members and other center personnel would come to Johnson for approximately four to six months. In addition, the skunk works should, to the maximum extent possible, utilize the organizations of Johnson and the centers.

During the Space Station Management Workshop several concerns were expressed. For example, Robert Freitag, representing headquarters, emphasized that "we should think international in the procurement of Phase B, as well as SE&I, design, etc."[14] Thomas Moser of Johnson was concerned whether adequate time existed to perform the necessary in-house systems engineering tasks and generate associated products for the RFP by July 1984, as the skunk works was expected to do. Ronald Browning of Goddard noted that the technical panels proposed as part of the formal space station Level B organization might dilute direct management authority and control. Jerry Craig stressed that budgetary issues, that is, who actually controls the budget, needed to be worked out.[15] And the role of the Department of Defense was still not clear. Despite these concerns, most people considered the workshop at the Lunar Planetary Institute to be a success.

The center directors did not attend the Space Station Management Workshop. They were present, however, when Bob Goetz summarized the workshop's recommendations in the management council meetings held in Houston.[16]

Many regarded the decision to form the skunk works to be the major accomplishment of the Space Station Management Workshop.[17] This was certainly true. However, a number of other things were also accomplished. Work began on program management details, and several options for the procurement strategy, as well as for the organization of Level B, were identified. Many of the options and alternatives developed during the workshop became the background from which the program management defined its structure and function. Over and above this, the notion that the space station program was an agency-wide program became more detailed in the meeting.

Skunk Works Begins

When the skunk works began in Houston, the program manager, Neil Hutchinson, and his deputy, John Aaron, assumed its leadership.[18] The skunk works focused on refining the broad details outlined by the CDG. The Space Station Management Workshop had already set forth the idea of a reference configuration, which would be an initial station configuration against which alternate ones could be compared.[19] As the CDG had been short-lived, its output was quite rough. Jerry Craig, for example, commented: "It was kind of—not detailed. The concept was an $8 billion space station. You could argue whether it was 8 or 10, but it was right in the ball park."[20] The reference configuration that the skunk

works produced would have to be much more detailed because the RFPs and the evaluation of the contract and proposals for Phase B would be based on the reference configuration they produced.

To gear up for the skunk works, Hutchinson was briefed by Griffin, the director at Johnson. Hutchinson had to work very closely with Clarke Covington who understood and led the contingent from Johnson Space Center. Jerry Craig, who had conceived the plan during the days of the PPWG, was part of Hutchinson's management team.[21] By then Hutchinson had picked Allen Louviere from Johnson to head systems engineering, and others soon followed.

Staff for the skunk works had to come from all the field centers. Centers could send as many people as they wanted, and there ended up more people in the building than there was space for. "And some came in and worked for a month and left and went home. Some stayed throughout the time."[22] John Aaron observed that there were "about 200 to 250 people, depending on what day you counted. About half were from JSC, in round numbers, and about half were from other centers."[23]

The skunk works was intended to assemble personnel with technical talent in differing areas of expertise, and physically isolate them from the rest of NASA's activities so that they could concentrate on a specific mission. According to many, that is precisely what happened.[24] John Aaron summed it up well.

> And good things happened, to our surprise. There was a lot of hype before that about the fact that the agency does not really have that kind of talent. But you aggregate people at that level in one place, strip them of their superstructure, which tends to strip them of their agendas, and it's amazing what great things happened.[25]

People worked well together in what was considered a very positive environment. They worked side by side and were very busy. Opinions came from various centers on the matters at hand. There were differences in concepts and that created a lot of discussion, but it was a good environment in which to work.[26]

During the skunk works Hutchinson showed glimpses of his leadership style. A former flight controller, he was accustomed to making detailed decisions. This trait carried over into the skunk works where Hutchinson was intimately involved in the technical details of the space station reference configuration. Consistent with headquarters' demands, his goal was to build a relatively strong Level B program organization. He kept in touch with his center director, Griffin, but would not allow himself to be perceived as a "JSC person" because he wanted all centers to have a fair hearing in decisions pertaining to the station.[27]

The skunk works retained many of the task force's characteristics, the secret of skunk works being not to manage it very much.[28] Individuals were organized into several teams: engineering, utilization, operations, procurement, and the other functions that needed to be addressed.[29] Hutchinson then challenged the team to go off and develop the configuration.

> So in that context it was a collection of teams, but it wasn't really organized in the normal sense of the work other than we had groups worrying about engineering accommodations or utilization or the requirements of the users, operations, procurement angle, and so forth. That's how we got to the point of arriving finally at a reference configuration.[30]

The skunk works' unstructured organization was quite conducive to the intense discussions that took place over the reference configuration.

During the skunk works Hutchinson built two coordination devices which later evolved into Level B's formal coordination mechanisms. The first, the skunk works senior staff meeting, consisted of senior members from all the field centers, including Langley, Ames, Kennedy, and JPL, centers which did not

subsequently play a role in the work package decisions. The staff meeting was formed to democratize decision-making on major issues such as the configuration. "Hutchinson went around the room and asked for opinions about major decisions such as the power tower versus delta."[31] Although it was unclear to some why centers having no accountability were asked to vote, on the whole the perception of the decision-making as democratic stayed with many on the staff. Although democratic, the decision-making process in these senior staff meetings was interesting: those who were present got a chance to vote, those who weren't did not vote. This pattern persisted as the senior staff meeting folded into the Space Station Control Board (SSCB), the major integration mechanism in Level B.[32]

The second coordination mechanism that evolved during the skunk works was the oversight committee, composed of nine members, representing agency-wide interests and chaired by Phil Culbertson.[33] The committee met with selected members of the skunk works (i.e., Neil Hutchinson and some of his team members) every two weeks to assess their progress. Although extensive documentation is characteristic of the space station program, the oversight committee did not formally document anything other than assigned actions. It was not unusual, therefore, that "you'd find a piece of paper that was signed appointing an oversight committee. That's probably the last you'll hear of it."[34] The oversight committee did not supervise the skunk works, but where the committee differed with the skunk works approach, it recommended not that skunk works stop, but that it do the committee's bidding as well. It was perceived that some of the work was done to the specifications of the oversight committee not because it had power over skunk works, but because the committee involved people who had the authority to get things done.[35]

The skunk works witnessed the maturing and evolution of the reference configuration that had been initiated by the CDG. Although Johnson and Marshall had their preferred configurations, the configuration known as the power tower emerged from the skunk works. The power tower configuration maximized the accommodation of user and growth requirements while demonstrating design and operations characteristics. To some extent this symbolized the need to incorporate user requirements into the station's design. Johnson and Marshall were quite content to keep the power tower configuration, even though it differed from their plans.

Accomplishments of the Skunk Works

The four-month long skunk works was a period in the station's management history in which all the centers participated without field center interests dominating the decision making process. A period of frenetic activity, the skunk works produced several concrete results. It gave birth to the power tower reference configuration, and this was no small task. All the centers were involved. The power tower configuration was a small triumph for the idea that the station was to be user driven.[36]

During the skunk works period the contours of the Level B organization in Houston took shape, and Johnson personnel filled over half the leadership positions. The complete management structure was in place during the skunk works, a structure that was ready to go back into Johnson Space Center and, with a small additional staff, launch Level B.[37] The skunk works also produced an initial planning document for the detailed definition, or Phase B, activity.[38]

Although the skunk works was physically separated from the rest of NASA, it was not completely immune from environmental pressures or from the workings of the agency. For example, in addition to analyzing the major configurations, skunk works personnel received an additional task. The House of

Representatives passed a $155 million bill in late May 1984 that authorized work on a comprehensive manned space station. The House Appropriations Committee had added studies for a man-tended station to those already existing in the bill for a permanently manned station, so NASA was required to conduct studies for an unmanned facility in addition to the studies already under way. Proponents of the man-tended option argued that such studies provided more choices for space activities if NASA's funding were reduced at some point in the future.[39]

The skunk works' time frame paralleled the division of the space station into work packages. The configuration born in the CDG underwent extensive revisions during the skunk works. The configuration now had much more specificity, enabling a more informed work package split. It was, therefore, not surprising that information from the skunk works was used by the center directors and the associate administrator in their decisions regarding the work splits. This information also influenced the procurement concept developed by the skunk works. For an integrated spacecraft, called a power tower, to be split into work packages, the agency would have to do a distributive analysis of SE&I.

Production of the RFPs, one of the main tasks of the skunk works, had to take into account the fact that division into four work packages meant added difficulty in managing the contractors. The agency would have to have four procurement packages, and the integration of these four different packages would have to be done in-house. The interfaces among the work packages would need to be clearly identified, a task that could not be accomplished at the skunk works stage. Although they had decided on power tower as the reference configuration, it lacked the specificity needed to clearly identify interfaces. John Aaron remembered that "at that point the fundamental question came up about the role of the program management organization called Level B."[40] Level B had to be a systems engineering organization that had the span of the total program and would balance resources and the engineering problem. The procurement concept ultimately decided upon during the skunk works involved sending out a single RFP, even though one work package would be associated with each of the four main centers.[41]

Although the skunk works accomplished what it set out to do, some participants had misgivings about its results. The power tower configuration was a radical departure from the one that the CDG had presented,[42] and this change was seen by many as the cause for the increase in the cost of the space station program. Moreover, to many, the products of the skunk works could not be disassociated from the results of the work package decision.[43] Thus, it seems that it may have been too early to divide the program into work packages. Why couldn't NASA have waited until the studies from the contract in Phase B were available before the work package decision was made? Finally, although the skunk works produced a program plan, and even an organizational plan, in retrospect many noted that they were rarely used when Level B went into effect.[44]

As was envisioned in the management workshop held earlier, the skunk works kicked off the Level B activity. The contours of Level B were beginning to take shape.

CHAPTER 8

FORMATION OF THE HEADQUARTERS PROGRAM OFFICE

After President Reagan, in January 1984, directed NASA to build the space station, NASA took steps to create a permanent program office. Phil Culbertson was chosen to be the associate administrator for the space station, and the Space Station Task Force was folding into the program office at headquarters. James Beggs had asked Culbertson as far back as 1981 to head up the space station program.[1] For Culbertson this was a dream come true: as the third man in the administrator's office, he had long desired to manage the space station program. Up until Beggs and Hans Mark were appointed, Culbertson's job had been to serve as a liaison between the shuttle program and the administrator's office. The shuttle had been delayed, an area of great concern to the Carter Administration, and Culbertson was asked to leave the shuttle office, where he had been the technical deputy associate administrator assisting Allan Lovelace, NASA's deputy administrator, in a more direct involvement in the program. When Beggs and Mark assumed NASA command, therefore, Culbertson sat in the administrator's office "without any really apparent job" because at that time the Reagan Administration did not want to be heavily involved in shuttle affairs.[2] Culbertson continued to write all the monthly reports, however, and met regularly with White House officials. Although Culbertson's position, that of associate deputy administrator, was known as the third man in the agency[3] and was the top nonpresidential appointment, Culbertson himself did not view it as a senior position since to him it was a staff job, performing administrative functions within the administrator's office.

Upon their appointments Beggs and Mark agreed that Culbertson could represent the administrator's office on the space station program, which was at that time in the advanced programs office in the Office of Space Flight, thus allowing Culbertson to stay involved in the technical side of things as well, "doing the things that the administrator and deputy administrator didn't want to do."[4] This is how Culbertson had become the associate deputy administrator, with the responsibility for overseeing the space station program and the task force until NASA created a permanent office.

A casual look at headquarters' organizational chart may suggest that Culbertson had been demoted by accepting the position of associate administrator.[5] Culbertson, however, did not see this change as a demotion or even a sacrifice.

> I did not feel that [it was a sacrifice] because I wanted to manage it [the space station office]. I was anxious to manage the program and I felt it was a greater challenge. Less prestige, but a greater challenge, and more fun to do than be a staff officer in the administrator's office.[6]

It came as no surprise to John Hodge, Robert Freitag, and the members of the task force when Culbertson was named the associate administrator.[7] Culbertson had been a sort of "godfather" to the task force. To others, however, it was a complete surprise that John Hodge wasn't picked to be the associate administrator.[8] There was a general belief that the director of the task force would become the "AA," and this had not happened, even though most of the strategy had been worked by Hodge and Freitag. The passing over of Hodge and selection of Culbertson to head the space station program was an indication that Hodge's influence was waning, as had been the perception to some in the centers.[9]

During the task force period, Culbertson had delegated to Hodge very broad responsibilities for the space station program. However, once the program office took shape, he planned to take command. In doing so, Culbertson was very aware that his management style differed from that of Hodge. Hodge's

style was loosely unstructured, whereas Culbertson's was more highly structured. To Culbertson, "John was much more willing to invite a lot of people into decisions. He always wanted all the centers involved in decisions. I am willing to listen to centers, but I don't want them to make the decisions. I believe in a single point for decisions to be made."[10]

Culbertson had worked for NASA for seventeen years and really believed in NASA's established operating style. He also had a realistic understanding of his own knowledge and skills, and would have preferred to have had more experience at the centers. Many of his subordinates understood that Culbertson was dedicated to the idea that the NASA system would work or could be made to work. Culbertson delegated and relied on the people to whom he delegated. Many believed his style of management was "institutional" because he relied on bureaucratic mechanisms to produce desired ends in the space station program.[11]

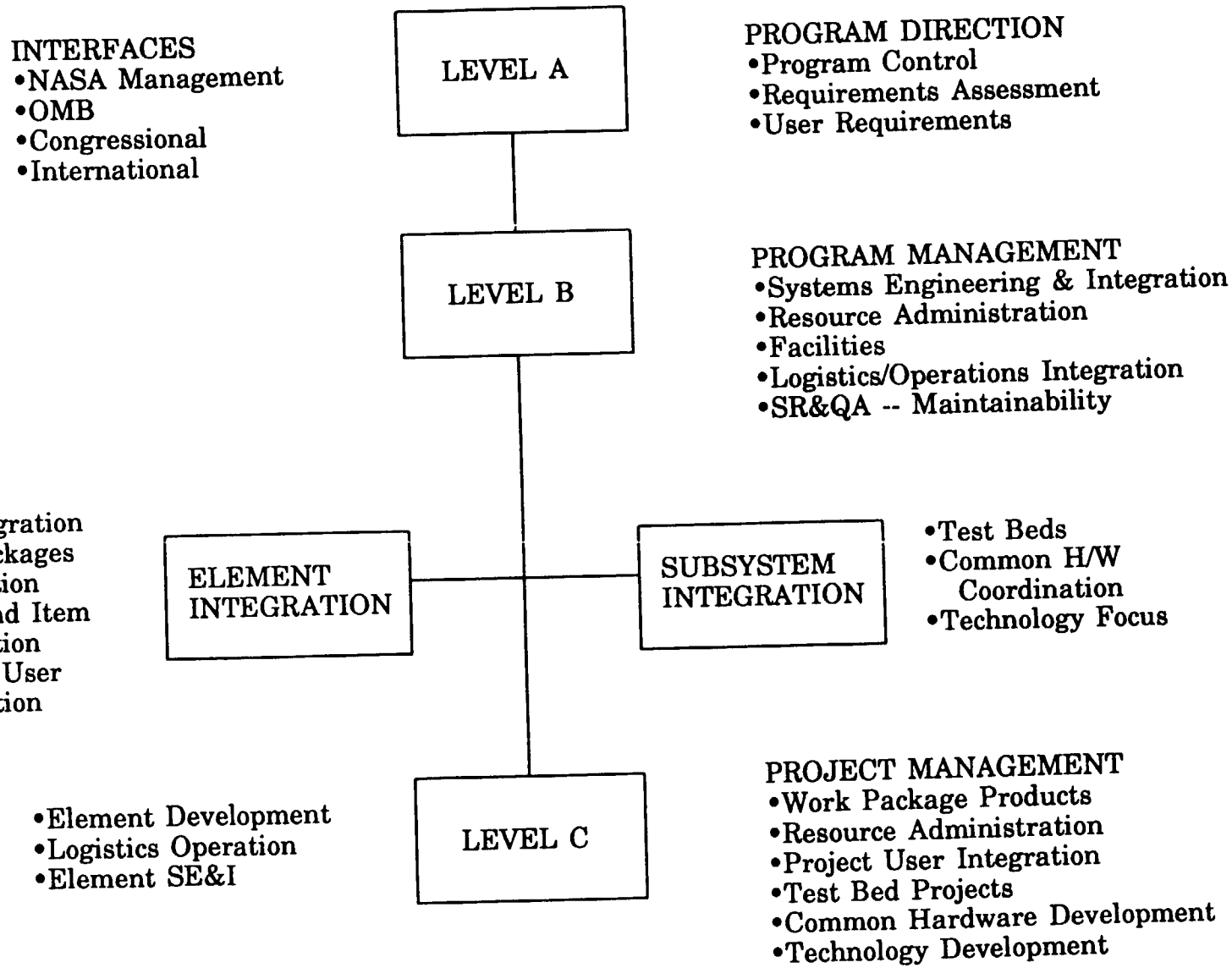
Yet there was another side to Culbertson which only some of his closest subordinates perceived. Culbertson was very careful of the feelings of others. He measured his words and chose his speech so as not to cast bad light if possible. His first act as associate administrator was to ask Hodge to be his deputy. Hodge, who had worked closely with him as his deputy, noted that "Culbertson would never harm anyone."[12] Culbertson would later say that that "was both his strength and his weakness."[13]

As the Space Station Task Force made the transition to a permanent office at headquarters, the members of the task force had to adapt to a new leadership style. To the "mavericks" of the task force this was a difficult transition. Hodge believed he had brought innovation to a growing and maturing bureaucracy. The task force had been set up outside NASA's bureaucratic confines, and the dynamics of leadership encouraged "bucking the system" whenever it was necessary. Now that the program had moved from the conceptual to the definition stage, a return to the bureaucratic norms was inevitable. And not only had the style of leadership changed, but the program had moved from the conceptual phase, in which innovations were necessary, to the hard work involved in the detailed definition period.

After President Reagan's directive to NASA, the agency began to organize the permanent office. As a result of the task force, NASA had agreed on the principle of the three-tiered organization structure. The three tiers—Levels A, B, and C—had differentiated functions. "Headquarters [Level A] would look out and direct, the main purpose was to protect Level B from the political environment and allow them to go do the technical job."[14] The program management rested with Level B, while the contractors were managed by the work package centers, who composed Level C.

Calling the levels A, B, and C represented a departure from the traditional NASA practice of differentiating the levels into 1, 2, 3, and 4 (figure 3), but the three-tiered arrangement for the space station was in conformity with the agency's historical practice. Level 1 was headquarters management, which involved overall budgeting, securing program approval, public affairs, and in general managing the agency's environmental interface. Level 2 was overall program management. Level 3 was the individual contracting group at the major centers, and Level 4 had been the contractor. So in comparing the two management plans, the partitioning of functions across the levels more or less conformed to NASA's historical practices.[15] For the space station program, the nomenclature differed because those that set it up wanted to show that this program differed from the shuttle. "We thought our A, B, C, D would be different from their 1, 2, 3, 4, and it was different. And if we had called ours 1, 2, 3, 4, people would immediately say, 'Our 1 is the same as their 1, our 2 is the same as their 2,' and they were not quite the same."

Space Station Dual Integration



Source: Space Station Management Colloquium, September 22-24, 1984

Figure 3

The major difference between the two centered on the role of SE&I. According to Freitag,

> The systems engineering is an analytical and an engineering task, whereas the integration can be not only analytical, but it can be an inspection, testing, acceptance type function, that may have a tremendous amount of activity at the center, and the headquarters. ... Knowing that those things were possibilities in the future, we didn't want [to be restrained by] their old nomenclature because we knew ours was apt to be different, and we didn't want people thinking they were the same.[16]

The permanent Office of the Space Station was not formally established until the summer of 1984 because the office could not be set up without congressional budgetary approval.[17] So, as the skunk works progressed in Houston, Culbertson and his deputy, Hodge, undertook different activities related to the role of the headquarters organization. Culbertson interfaced with Beggs and was involved in budgetary matters, working with the Office of Management and Budget (OMB) and Congress to make certain that the following year's budget was in line with NASA's projections. Meanwhile, Hodge considered the external aspects of the program. He was involved with the international agreements and the user community, as well as with the Space Science Board, Science Applications Board, and continued to interface with the DOD.[18]

Of course, Freitag and members of the task force assisted both Culbertson and Hodge during this period.[19]

Structure of Level A

The Office of the Space Station at headquarters was structured similar to NASA's other program offices. It consisted of an associate administrator and a deputy associate administrator who were accountable for the space station program. Two staff offices—the policy and plans and program support—assisted the associate administrator in his relations with Congress, OMB, DOD, and eventually the international partners. Four line offices reported directly to the associate administrator: the business management division; engineering, utilization, and performance requirements; and an operations division. The last three offices were keepers of the space station requirements. The policy guidelines that Level A was in charge of, and that Level B implemented, emanated from these three divisions. In addition, a chief scientist position was established to support the associate administrator's office and interface and be the protagonist for the "users" (i.e., the scientific community) so that the definition period was responsive to user requirements.

There was, of course, some reason for concern on the part of the users. Burt Edelson, associate administrator of OSSA, had expressed his concern to Beggs over the ability of his and related program offices to effectively participate in the program. OSSA had envisioned that major benefits could be provided by a properly implemented space station program, and believed it imperative that the space station structure included ways for various NASA program offices to influence its design and to support its development.[20] Edelson expressed his concerns in a memo to Beggs, and he later outlined several techniques to bring this to bear on the space station program.[21] Beggs referred the matter to Culbertson. Even though Culbertson was "sensitive to the needs of the user," he noted that the management would be better off with a single chain of command and that Edelson's concerns could be worked out within the existing scheme.

In the end, such concerns notwithstanding, the structure of the Office of the Space Station was quite similar to the one that the Space Station Task Force had originally recommended.

Staffing

When the Space Station Task Force folded into the Office of the Space Station, some key task force people moved into positions in the permanent office. John Hodge became the deputy associate administrator. Danny Herman, with his systems engineering background, headed the engineering division. Terry Finn, the architect of many of the task force's political strategies, was one of the leaders in the policy and plans office. Not all the offices were manned by task force people, however. Culbertson appointed William Raney to lead the utilization and performance requirements division, and David Black became the chief scientist.

Although the original estimates to staff the Office of the Space Station ran near a hundred, by the time Administrator Beggs made his decision, he was willing to place only sixty individuals in that office. Culbertson later requested an increase of fifteen permanent positions for the Office of the Space Station.[22]

Program Office Gears Up

Initial organizing efforts for the program office took place at headquarters amid the hustle and bustle of operating activities. Although the three-tiered structure of the space station program management had already been decided, critical questions regarding the detailed tasks to be performed at each one of the levels, and the interfaces among these levels, especially Levels A and B, had not yet been worked out. These organizing efforts focused on specificity within jobs and the interconnections among various tasks that needed to be done.

Louis DeAngelis, the head of NASA's Office of Human Resources and Development, helped in organizing a process by which details of individual relationships could be defined. This process came to be known as Cycle Zero.[23] Hodge described DeAngelis as "the personnel type, the people type, who really understands management from a people point of view."[24] Hodge described Cycle Zero. "It's where you don't write an organization, what you do is you write the job to be done and you lay out the job with the interconnections between the pieces of the job, and as a result of that, you automatically have an organization."[25] So, in a sense, it was a backwards way of doing things. To get the organization sketched, people were assembled and the jobs were defined.

Of course, by then the task force members had discussed how they were really going to manage the program once Phase B ended. The focus mainly centered on the relationship between Level A and Level B, and who was responsible for what. In traditional management circles, this is often referred to as responsibility charting. It involved a collaborative process to decide the jobs to be done, to determine who would do each piece of the task, and what the interfaces between the jobs would be.[26]

A series of documents, often referred to as the John Aaron Matrix, came out of these meetings. Hodge "had tremendous hopes for it. And it certainly got people thinking the right way, but it never really came to closure. Never really did. And to this day it hasn't."[27] Although this process was not new to NASA, Hodge felt that this was one of the very few occasions when the activity was so well organized. Usually "that was done with a bunch of the good ol' boys sitting down and splitting it up without understanding really what the impact of their decisions were."[28]

Interface Between the Space Station Office and the Program Office

In addition to the structure of the space station office at headquarters, interfaces between headquarters and the program office at Houston received attention during this period. The links between the associate administrator and Neil Hutchinson, the program manager, were constructed. Interfaces were also developed between the engineering, utilization, and performance requirements, and between the operations divisions at headquarters and their respective counterparts at Level B. Dominating these interfaces was Culbertson's decision regarding Level B's role and functions. True to NASA's historical practices, Culbertson wanted to strengthen the program management and protect it from Washington's political pressures.[29]

In the space station program there was an additional complication. Hutchinson had a conflict of interest between the program and his own career path. This was a natural outgrowth of the decision to have the lead center at Johnson, as well as a work package at Johnson reporting to the center director. Since Level B was in charge of the overall project, it had to make judgments among the work packages at Marshall, Lewis, Goddard, and Johnson, and created conflicting demands for the program manager. The program's requirements pulled him in one direction, while his own career, which was controlled by the director at Johnson, frequently pulled him in the other. Culbertson appreciated this conflict, and he also recognized that there would be a continuing struggle between Level B at Johnson and the Level C centers as they sought to increase the activities over which they had control. He decided that for the overall health of the space station program he should make the position of program manager as strong as possible. He gave Hutchinson as much authority as he could to show that he supported Hutchinson as director of Level B. Although in retrospect Culbertson saw that in giving Hutchinson so much authority he weakened himself as associate administrator, at the time it was a very deliberate action.[30]

Other decisions also cemented the interface between Levels A and B. For example, the utilization and performance requirements division assimilated user requirements, which then had to be interpreted by its corresponding office at the program level. The requirements that were generated at the operations office at Level A also needed to be translated by its corresponding office at Level B. Within this multiple context, insofar as the program was concerned, Culbertson allowed the primary contact between Level A and Level B to be through himself and Hutchinson.[31] He believed that this strengthened Hutchinson's position. Culbertson's decision thwarted DeAngelis' earlier efforts, but it was consistent with Culbertson's aim to maintain a single decision point in the organizational hierarchy.

To others in the task force, however, Culbertson's decision appeared to undo all the start-up work that they had done earlier. Ostensibly those activities tackled a classic issue in multi-tiered organizations: the relationship between the levels. How do Levels A and B, with somewhat overlapping functions, link up? Should they connect through the individuals heading the respective levels, or should there be a multiple contact level incorporating the offices in charge of operations, engineering, budget, and customer utilization, offices that had a linking mechanism? Culbertson decided to structure the contact primarily between the heads of levels, thus undoing for the most part the earlier activities. This meant that whenever there was a disagreement between an expert at Level A and an expert at Level B, it was always resolved with Hutchinson going to Culbertson.[32]

Budgets were a second mechanism by which Level A interfaced with Level B. Given the three-tier structure of the space station program, each level required budgets for performing certain kinds of jobs. On the whole, the responsibility for putting the budget together rested with Level A at

headquarters. Level B took most of the dollars because, after all, the contracts were managed at the field centers, and the program office was empowered to coordinate these activities. After the budget was approved, Level A's money came off the top. The remainder went to Level B, which then administered the budgets for the work packages. Since Level A had the main budget responsibility, however, this meant it had leverage and could insist things be done that Level A felt were important. Bones of contention included automation and robotics.[33]

As with budgets, the space station office at headquarters controlled some of the key program milestones. These milestones, the results of the Space Station Task Force's efforts, were already formed by March 1984.[34] They served not merely as an interface mechanism between the levels, but also as a means to control the progress of the Phase B definition study and to keep the program on schedule. In August 1984 the responsibilities for Levels A and B, the budgets, and the milestones, were signed into agreement between the Associate Administrator for the Space Station Phil Culbertson, Gerry Griffin, center director at Johnson, and Neil Hutchinson.[35]

Consistent with Culbertson's desire to make Level B strong, Hutchinson and Griffin did most of the recruiting for Level B. Although Culbertson was always consulted before senior positions at Level B were filled, Level A, in general, had little input in the selection process. There was, however, one major exception. Bill Raney, who headed up the user requirements office at Level A, had asked for names of those being considered for his counterpart position at Level B and was given the opportunity to comment on the candidates.[36] Carl Shelley was eventually selected for the position.

Shelley's first assignment was to go to headquarters where he attended a workshop and met potential users and all the organizational user sponsors. He learned that there was a lot of dissatisfaction with the way the manned space flight function within NASA treated users. Because of Shelley's early contact with the user community a comfortable relationship was established between the users and the two offices within the space station program.[37] This input to the selection process at Level B and the subsequent orientation was not commonplace in the space station program.

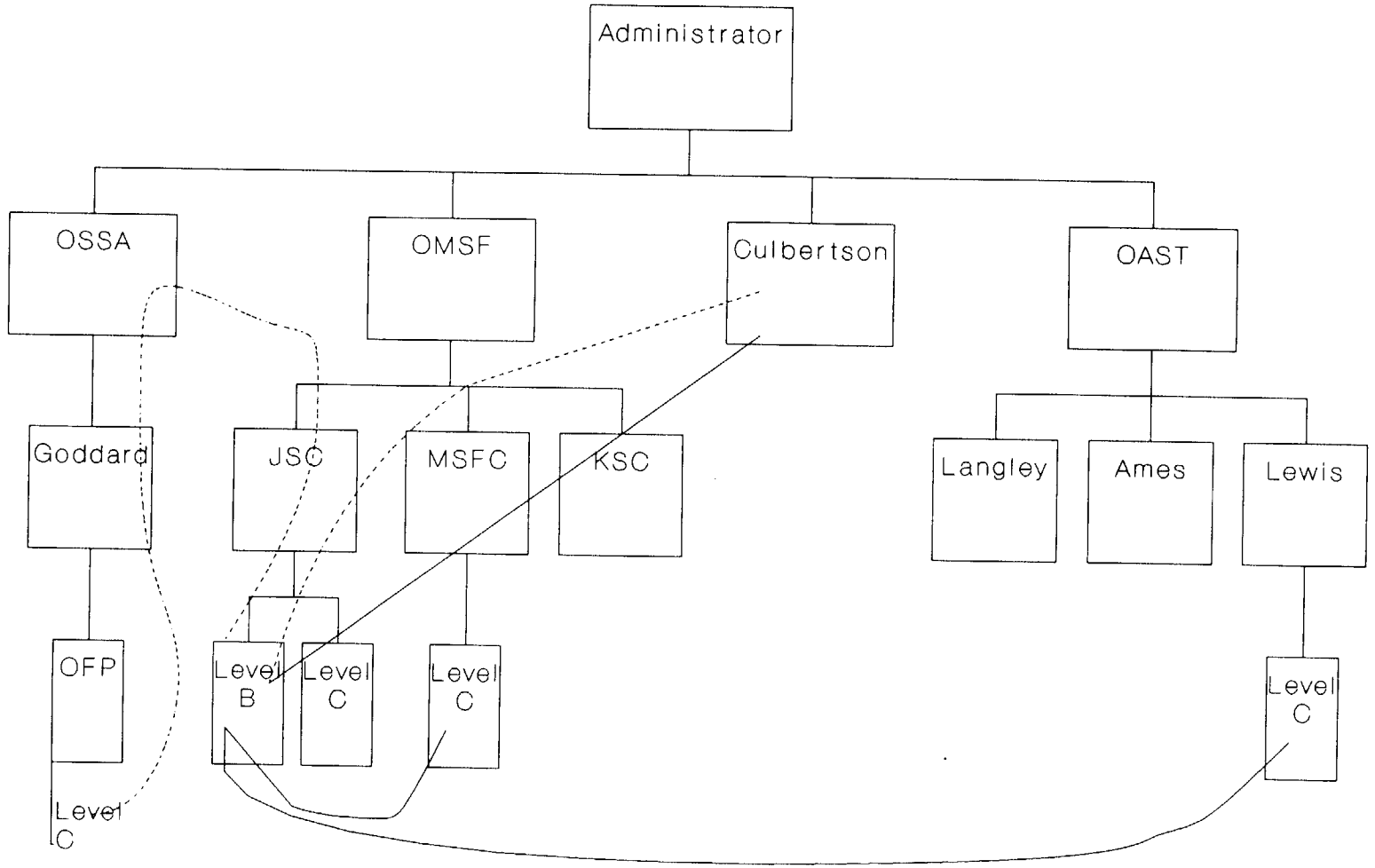
The interface between Level A and Level B were not Culbertson's only concerns. During this period he made institutional arrangements in order to clarify and strengthen the relationships between headquarters and the center directors.

Institutional Linkages

Culbertson had reason to focus on building institutional linkages for the space station program. In 1984, the center directors reported to either the associate administrator of OAST, OASS, or OASTS, in charge of, respectively, the science, technology, and development programs. Although the space station program was an agency-wide program and would assume importance in later years, none of the centers reported directly to Culbertson when he became the associate administrator. They all reported to other associate administrators. Since the Level B and Level C offices reported to a center director, Culbertson had to rely on the cooperation of other associate administrators to implement technical space station policy. Because the center director reported to an associate administrator, Culbertson, who was accountable for the space station program, did *not* have a direct institutional line to the program manager (see figure 4). Culbertson explained his dilemma.

> And here I was Associate Administrator for the Space Station, and I had my work going on at the field centers, all of whom reported to somebody else at my same level. At Houston the organization consisted of a center director at the Johnson Space Center, and then he's got a

Space Station Organization
(from Culbertson's perspective)



- - -> The legal route (applicable to all 4 work packages)

——> The working route

Figure 4

> bunch of subordinates that report to him, but one of them is my program manager, Level B person, who is looking at the entire space station. ... The lines of authority that we tried to make happen were that I directed [the program manager], who in turn was trying to direct the efforts of [the four Level C project managers], who had responsibility to do the details. But from the administrator's standpoint, he was holding the center director at Goddard responsible for the overall work that Goddard did. So in fact what we found was that the only way we could formally provide direction was ... I just directed the center director, he directed Level B, and Level B, through the center director, directed those other center directors, who directed their people. In a very ritualistic way that's the way it had to happen. Fortunately we normally had enough sense to ignore the ritual and work problems directly. But there was always a lurking threat that the system would break down.[38]

Since the space station program relied on the institution, and the institution itself was represented by two different offices, Culbertson formalized the practice of dual interface mechanisms. The first was the Space Station Steering Committee; the second was the Management Council. The Space Station Steering Committee, which had existed during the task force days, comprised primarily associate administrators drawn from various program offices.[39] It served to keep headquarters program offices informed of the space station's progress and to solicit the advice of the other AAs. After the task force became the program office, the Space Station Steering Committee continued, and its attendance improved.[40]

The Management Council also provided institutional linkages. Culbertson was sensitive to the fact that NASA's technical expertise lay at the field centers, who would ultimately manage the work packages. Therefore, the institutional leadership at the centers had to be coopted into the program. To accomplish this, the Management Council, consisting of the directors of the centers involved, was formed. The council was formally established in November 1984, but informally had met as far back as the Langley meetings. In these meetings Culbertson stressed information that needed to be reinforced at the project office level, such as the importance of the users' requirements in dealing with the contractors.

Early Accomplishments of the Level A Program Office

The program office accomplished a number of things before the Phase B contractor studies began. Some were continuations of the task force's activities, some were new initiatives begun after President Reagan's address, and some were thrust upon NASA by Congress and other pressure groups. These accomplishments fall into three categories: 1) international participation; 2) user requirements; and 3) congressional mandates.

International Participation

The seeds for international participation had been sown before the Space Station Task Force was formed. Working level discussions between NASA, the European Space Agency (ESA), Canada, and Japan, had occurred from 1982 through 1984, prior to President Reagan's decision to go ahead with the space station. The talks culminated in 1984 when President Reagan, in his State of the Union Message, invited U.S. allies and friends to participate in the program. In the spring of 1984, Jim Beggs, along with a number of others from both inside and outside NASA, visited Europe, Canada, and Japan and joined in high-level discussions on international participation. The space station was also discussed at the 1984 London Economic Summit.

In April, Culbertson established the Working Group for International Cooperation, chaired by Robert Lottman.[41] Its objectives, according to Culbertson, included the development of management plans and schedules for the definition phase, evaluation and support for policy development, technical analysis, and participation in the negotiation of international agreements.

The pace of these international negotiations was hectic. In June 1984, space station personnel and European, Canadian, and Japanese government representatives met for the first time since the London Economic Summit. Following this meeting, the Working Group on International Cooperation reviewed the language of the RFPs emerging from the skunk works and began to draft a Memorandum of Understanding for the Phase B RFP.

The international negotiations were led by Margaret "Peggy" Finarelli, under the overall direction of Bill Raney, and with the assistance of a number of people, including William E. "Gene" Rice, representing Level B in the Program Office. In the spring of 1985, ESA, Canada, and Japan signed the Memoranda of Understanding with NASA. It provided the framework for international cooperation on the space station during Phase B.[42]

While these negotiations were going on, the program office at headquarters was also wrestling with the issues of managing the international partners once they came on board. The first question the program office had to tackle was how to treat the international partners. Should the European, Japanese, and Canadian efforts be treated like the other work packages and be integrated into the management structure in a manner similar to the other four work packages? Or should they be put in a position where their laboratory work would be done at Level C, the place our lab work was performed? From a headquarters point of view, the latter solution would have been simpler, but it was politically impossible to do. The international partners wanted to be seen as true partners. They did not want to play a role which seemed to be at Level D.

The second issue the program office had to deal with was the degree to which NASA should strive for commonality or interchangeability between foreign and American laboratory parts. The question of commonality became an issue because the Europeans did not want NASA dictating what particular design or what components they were going to buy. The basic principle of international participation has traditionally been one of no funds exchange. That is, Europeans did not have to buy U.S. components for their laboratory. However, if there was no attempt at commonality, then the logistics and spare parts problem would increase dramatically. This would also affect training for on-orbit repairs.[43]

A third management issue related to the exchange of technical data in the international sphere. The concern that the DOD had over technology transfer was going to be an issue,[44] and the program office had to decide how to deal with it.

Focus on the Users

Responsiveness to user requirements was one of the guiding principles of the space station program from the very beginning. When the program took shape, there were two objectives vis-a-vis the users. The program had to continue to be responsive to the users so that the space station program's funding could be stabilized over the years. There was also a need to incorporate user requirements in the station's definition stage. Before the Phase B studies began, the program office undertook several initiatives to accomplish both these objectives.[45]

To sustain the user constituency, the program office continued initiatives that the task force had started. Because of its visibility in Washington, the scientific community continued to be important.

Under the auspices of NASA's OSSA, an advisory committee on space station, called the Task Force on Scientific Users of the Space Station (TFSUSS) was created from the extant advisory committee, SESAC. TFSUSS was chaired by Peter Banks, Professor of Electrical Engineering and Director of the Space, Telecommunications, and Radio Science Laboratory at Stanford University. The Banks Committee, consisting of some twenty U.S. scientists and several international observers, assisted NASA in planning the station's scientific utility, and served as a focal point for scientific input into space station activities. It also clarified the relationship between new capabilities and the existing science and applications program and periodically updated scientific requirements.

Although it was clear, even during the task force days, that the scientists who had influence in Washington—i.e., space astronomers—were not really a user constituency, they were, nevertheless, potential users of the station. However, the space station opened up whole new lines of science and space endeavors—life sciences, material sciences—in ways that had never before been possible.[46] Compared to the older and more mature disciplines such as space physics, these sciences were relatively young. This meant that the constituency was young as well, and the continued support of (and lack of criticism from) the overall scientific community remained important.

The scientific community was not the only user group. "The support from users really comes in the folks who want to develop new technologies, want to do commercial things, commercial folks that want a chance to get to space."[47] Consequently, the program office established the Commercial Advocacy Group, another continuation of the Commercial Working Group which had existed as part of the task force. It was empowered to develop domestic and international commercial participation and functioned as part of the utilization and performance requirements division. By incorporating commercial users, NASA also encouraged private sector participation, a theme dear to the Reagan Administration.[48]

The continued efforts to nurture the user community produced tangible results. In May 1984, a group of scientists, led by Robert Jastrow of Dartmouth College, wrote to Congress in support of the space station's scientific merits. With regard to the commercial users, Space Industries Inc.'s Max Faget signed a Memorandum of Understanding in August 1985 to exchange information with NASA on their respective programs during the station's Phase B definition and preliminary design period.[49]

However, all was not smooth sailing. As the Phase B RFP was prepared, the Banks Committee had concerns over whether the user requirements would be adequately incorporated into the station's preliminary design and definition. Banks wrote directly to Jim Beggs, the President, and various newspapers, but he eventually came to believe that the user requirements were being incorporated into the space station definition.[50]

To incorporate user requirements into the space station definition studies, the program office initiated a series of workshops. The workshop at Hampton, Virginia, was designed to influence the RFP generation in the skunk works. Another meeting, held in September 1984, briefed user sponsors, both American and international. These workshops and associated Management Council briefings resulted in the functional requirements envelope, which was defined before the contracts on the Phase B studies started. The workshops also organized and refined the user requirements so that they could be meaningfully incorporated into the contractor studies in Phase B.[51] The early task force effort had sought to understand the data NASA had collected from its potential users. After the space station program was approved, user needs took on a more serious note. This is because now they were requesting dollar commitments for future use of the station rather than merely asking if sometime in the future they might be interested in using it and what would they like it to do.[52]

The early studies conducted during the task force period produced a large collection of potential uses for the station. On the engineering side, however, ideas were maturing about the space station configuration and its capabilities. The two sides had to reach some compromise. From Raney's point of view

> the first major thing to do was to try and understand what the users had told us, and then to guess as to what sort of functional capability the station should have, but stay away from specifying the design configuration and speak rather to general functions. And that had to do with, for instance, the level of power available for users, number of crew available for user functions, the channel capacity of communications, and what sort of repair work might need to be done on user equipment as well as space station equipment.[53]

These questions had definite design implications: whether to have a mobile crane of some sort to move things around on the outside, how big to make the doors to get equipment in and out, what kind of storage was needed for spare parts and workbenches, and the like. These were, in fact, the basic level of functional capability that the station required. A formal document called the Functional Requirements Envelope was produced in the spring of 1985[54] which was actually the beginning of the incorporation of user requirements into the station's design. As the contract studies began, it represented another early accomplishment of the program office at headquarters.

Dealing with Congress

Although by January 1984 President Reagan had given the go-ahead for the space station program, a number of battles were yet to be fought in Congress. The subcommittee of the House Appropriations Committee had not approved the money to pay for the facility. President Reagan had asked Congress to approve $7.5 billion in obligational authority for NASA for the fiscal year ending in September 1985. This included an initial request of $150 million for a permanently manned space station. Several members on the House Appropriations Committee were not favorably disposed to the permanently manned space station,[55] however, and so Congress produced some additional directives. Two additions impacted the space station program in a major way. The first of these incorporated an option for a man-tended facility in the Phase B RFPs. Stimulated by the efforts of Edward Boland from Massachusetts, NASA was additionally required to conduct a study on the man tended option. In an effort to appease those interested in a fully automated facility, the lawmakers also told NASA "to complete a second study on space station automation and robotics and spend no less than 10 percent of the cost of the facility on such systems." As President Reagan signed the legislation on July 16, 1984, approving what NASA officials believed would be the first incremental step toward a permanently manned space station, the legislation incorporated mandates to NASA to study both these options.[56]

NASA subsequently established the Advanced Technology Advisory Committee to examine the potential for incorporating these advanced technologies in the station and submitted its first report to the Senate Appropriations Committee on April 1, 1985, before the Phase B contractor studies began.[57]

The man-tended option presented its own management problems. First, there was the question of the concept of a man-tended station. As the space station idea had evolved during the task force days, laboratories and habitats (part of the space station) had been perceived as part of the manned system; the unmanned part was the platforms. The science to take place in the station—experimental science—generally required human presence. It did not consist of long-term instruments that would be set up and run for extended periods of time unattended. Culbertson strongly (and unsuccessfully)

opposed the man-tended concept because he considered it totally inconsistent with the purpose of the space station. Culbertson explained the changes that the man-tended option would require.

> All the characteristics of the space station that had emerged during the early days of the concept were the kind of science which required man's presence. Now ... we were told that we had to do this study of what could be done in the space station in a man-tended mode. Well, that meant that either we dreamed up a new class of science, new set of science experiments to go in it, or we were going to modify scientific equipment which was planned to be used in the manned mode, and we also had to modify characteristics of the space station to make sure it would successfully support these instruments during periods of man's absence.[58]

Now, however, there was the problem of trying to persuade Congress against the man tended option in light of NASA's opposition to that option. Culbertson explained:

> We were asked to do a study that most of us thought was a study of an illogical thing to do, and we knew that if we concluded that it was illogical or expensive to do, we would be accused of not doing a good study. We had to bend over backwards to try to make this concept that we opposed look as good as it could, or the study would be rejected. And that was difficult to do.[59]

As Culbertson wrestled with the issue, the first cracks in the space station program organization appeared, a precursor to future events. The skunk works had produced the RFP for the Phase B proposals. In the bustle of their activity, the operating skunk works did not worry about congressional mandates regarding the man-tended option, automation, and robotics. This had been forgotten, in spite of pressure from the headquarters program office.[60] Ultimately this was resolved by inserting the two options in the RFP at headquarters. As time went on, it was difficult for some of the members of the Office of the Space Station to understand why the man-tended option had not been seriously studied. The policy and plans office was concerned about this, realizing that NASA would have to submit something to the congressional committees before the configuration was selected.[61]

Culbertson solved the problem of political feasibility by establishing an ad hoc task force on the man-tended option, chaired by Richard Carlisle. The study was finally done at Goddard, not at Johnson. To many in the program office, however, Culbertson's thinking was not clear.[62] They wondered why Level B at Johnson had not been asked to conduct the study. Culbertson himself had two legitimate reasons. First, the study had to originate from a credible source, especially since NASA had opposed the man-tended option in the past. Second, he did not want the Level B studies to be mired down in considering the man-tended option, particularly in light of his own view that this option was really not a logical alternative.[63]

CHAPTER 9

FORMATION OF LEVEL B

John Hodge and the task force considered the process of program definition in early 1983, as well as the organizational functions to be carried out, and the staffing approach for the space station definition period. As Hodge saw it, the definition process would unfold over time and would move from user needs to mission requirements, which would then dictate the system requirements. The system requirements then would set the boundary conditions necessary for definition and configurations.[1]

With respect to staffing, Hodge expected to use incentives to attract NASA's best and brightest from all the centers and headquarters. Personnel rotation would keep a fresh outlook over time, although there would be a degree of permanence to ensure continuity.[2]

Although this thinking took place in early 1983, the actual organizing for program management (Level B) received serious attention only after Presidential approval of the space station program a year later. By then NASA had chosen the lead center concept for the program, which nullified Hodge's assumption that control of the program would remain with headquarters.

At the Space Station Management Workshop held at the Lunar Planetary Institute (outside JSC) in March 1984 an attempt was made to detail the structure of the program office. This three-day meeting, however, was too brief to allow anything except the broad contours of the program's structure to emerge. Much of the discussion revolved around how the program office should be structured in terms of its relationship to the lead center, Johnson, since participants were still enthralled by the lead center concept operating in the space shuttle program. Although these two themes dominated the discussion of organizational structure, the workshop also outlined a structure of the program office itself and examples of possible space station program management organization were produced.

The Space Station Management Workshop addressed the broad structure of program management and the coordination mechanisms that would be necessary between Levels B and A and between B and C. Although the idea that there would be four work packages had gained acceptance, the participants were uncertain as to how the work packages would be organized. Amid this general air of ambiguity, the members identified three critical organizational issues with respect to the Level B-C interface. These were: a) definition of in-house SE&I; b) the impact of advanced development and test beds; and c) the coordination mechanisms themselves. Program office activities during the definition phase were also roughed out.[3]

As the workshop participants debated tentative program management structure, they were awed by the extent of the SE&I to be performed by the program office during the definition period. Unlike the shuttle, which had clean interfaces, the space station, with its four work packages, had very complex interfaces. It was clear that the space station would present a systems engineering job that was quite complex and far exceeded the one NASA experienced during the shuttle program. Because of this complexity the staffing for SE&I at the program office would have to be much greater than that for the shuttle. The SE&I staff would have to integrate the many interfaces that had been created in the space station program. This included the interfaces created by the four work packages, in addition to those generated by the advanced technology development efforts at the eight test beds.

The Metamorphosis Begins: Skunk Works to Level B

During the skunk works the space station program management organization began to take form. Although the initial phase of the skunk works was devoted to developing a reference configuration, it also created a skeletal Level B organization. In fact, a chart of the interim Level B organization appeared in the draft of the "Space Station Program Initiation Agreement" that Gerry Griffin forwarded to the acting associate administrator for the interim space station office. The chart identified the support and line functions performed in the program office. The support functions included managing the RFP, administration, and program planning. The line functions included systems engineering and integration, cost analysis and budget management, advanced development integration, customer integration, and procurement. The informal organization also had the Office of International Affairs and Systems Requirements and Quality Assurances (SR&QA).[4]

During the latter phase of the skunk works, serious attention focused on the formation of Level B, an activity which paralleled the activity of the Source Evaluation Board (SEB). (The SEB will be discussed later in this chapter.) Since Neil Hutchinson headed the SEB, the organization of Level B was delegated to John Aaron.[5]

By this time Culbertson had formulated the initial work package splits which was a major part of Level B's coordination problem. As Aaron began to organize Level B, therefore, he had to be concerned with Level B's tasks and the appropriate allocation of work among the work packages. How should Level B and the entire agency fashion a coherent whole from the mass of data generated by the work package contractors' studies? Aaron explained the problem as he saw it.

> Right there at that point the fundamental question came up of the role of the program management organization called Level B. Is that a systems engineering organization that has the span of the total program, and therefore should be able to balance the resources and balance the engineering problem? Or was Level B's function one of splicing coordination and connecting parts and pieces that were designed and built in a distributive environment? The engineering prerogative question of Level B and the program management organization versus the centers and their projects came up very early. In fact, it was never really resolved.[6]

The lead center concept of program management hinged on the assumption that the center directors would cooperate and share their resources. Resource sharing in this context meant that the directors would put their best systems engineers at Level B. The work package splits decided upon by the associate administrator emphasized that the SE&I function would have to draw from all centers. Each of the work package centers would have to share its burden of SE&I at their own centers in addition to the SE&I job performed at Level B at Johnson. For example, the common module at Marshall required significant SE&I effort from that center,[7] and the power responsibility assigned to Lewis would involve its own SE&I effort.

Meanwhile, international participation also increased the complexity of program management. By the time that the skunk works ended it was obvious that the international partners would conduct parallel studies and that Level B would have to keep track of them and splice their recommendations into the definition of the space station configuration.[8]

The space station program increased in complexity once more with the inclusion of the Technical and Management Information System (TMIS) Project, an idea originally developed by John Hodge and the task force. John E. Cools was hired to start the TMIS project in Level B.[9] While the skunk works was in progress, Hutchinson established the Space Station Information Systems Requirement Panel, which was given the task of defining the administrative communications, engineering tools, and databases

that would be needed throughout the space station program. This panel, a continuation of the Information Systems Working Group, was charged with obtaining the statement of work and the requirements for the RFP for the Phase B contract. Cools' job was to coordinate and integrate the requirements of TMIS. He also defined the budget, the procurement process, and the implementation of operations. Cools held this position for about a year and a half, and in the fall of 1985 it became the TMIS project office.[10]

Evolution of Program Office Organization

The small interim Level B organization informally established during skunk works formed the nucleus of the larger organization once the Phase B study contracts were awarded. This organization performed major tasks before the beginning of the Phase B studies, including program planning, developing an organization, and activities related to procurement—i.e., preparing an RFP, the release of the RFP, the SEB, and the like. When the interim program office was established, the importance of the international dimension was already fully appreciated by NASA officials. Because of this there was already an international office reporting to Hutchinson, which was a departure from the Space Station Management Workshop's original intentions. The nucleus of the TMIS integration office was also in place at that time.

Two factors influenced the evolution of the Space Station Program Office. First, as we have seen earlier, Culbertson had decided that the Level B organization should be strong and autonomous.[11] With this understanding, Aaron initially, and later Hutchinson, began to build their program office at Johnson.[12] One of the recommendations of the Space Station Management Workshop was not heeded, so the program office did not rely on the JSC institution. It was not matrixed with Johnson, a factor noticed by personnel there. Robert Dotts, who helped organize the management workshop, was concerned that of all the successful options that they had developed, the one that Hutchinson and Aaron chose was "toward the more undesirable end of the self-contained." He found it frustrating that the time had been spent at the Lunar Planetary Institute meeting discussing Level B organization and all their work was being totally ignored. "I came back a couple of times from skunk works and said to Bob Goetz, 'Hey, you just wouldn't believe what those guys are doing. They're doing exactly opposite.'" Considering the extensive commitment of the JSC institution to the shuttle and the extremely difficult job before them, one can understand why the program office evolved to a more self-contained than matrix-supported organization.[13]

The SE&I task was complicated by a number of factors. Technological interfaces were complex, and they fell into two difficult groups. First, there were the major architectural components: assembly structure, laboratory modules, habitation module, and the free flying platforms. Second, there were a number of systems that cut across architectural components: power, data management, and the like. The two clusters generated multiplicative interfaces since they all had been distributed across four field centers.[14]

In addition, many of the station's requirements were expected to mature only during Phase B. However, studies of requirements imposed by emphasis on missions and operations took place and the international negotiations progressed. These studies meant that the requirements would be changing, and SE&I would have to adapt to those changes. For all practical purposes, in decisions related to configuration, SE&I became the final arbiter of the data generated from various sources: trade studies of work package centers, advanced development test beds, studies of user and operations requirements,

and even the international partners. As a result of these very complex interfaces, the Systems Engineering and Integration Office, reporting to Hutchinson, became the focus of the engineering activity conducted during the definition period.

As had been suggested by the Space Station Management Workshop, and consistent with the interim program organization operating during the skunk works, the Space Station Program Office that came into existence in April 1985, before the Phase B studies began, consisted of four main line functions: program management, customer integration, data management and operations, and SE&I.[15] There was one major difference, however. The workshop thought advanced development would be a separate line function within the program office. The interim program organization had functioned this way. Before the Phase B studies commenced, however, advanced development became a part of the SE&I function.

Each of the Level B offices had the primary task of coordination, although this was much more complex for the SE&I function during the definition stage. Coordination was achieved by a hierarchy of panels, structured, in many respects, by the panel structure formed during the shuttle development.

Coordination Mechanisms Within Level B

The program organization created a series of committees for coordinating the tasks Level B had to accomplish during Phase B. There were two kinds of committees: panels and boards.[16] They were hierarchically arranged in a pyramidal structure as shown in figures 5 and 6.

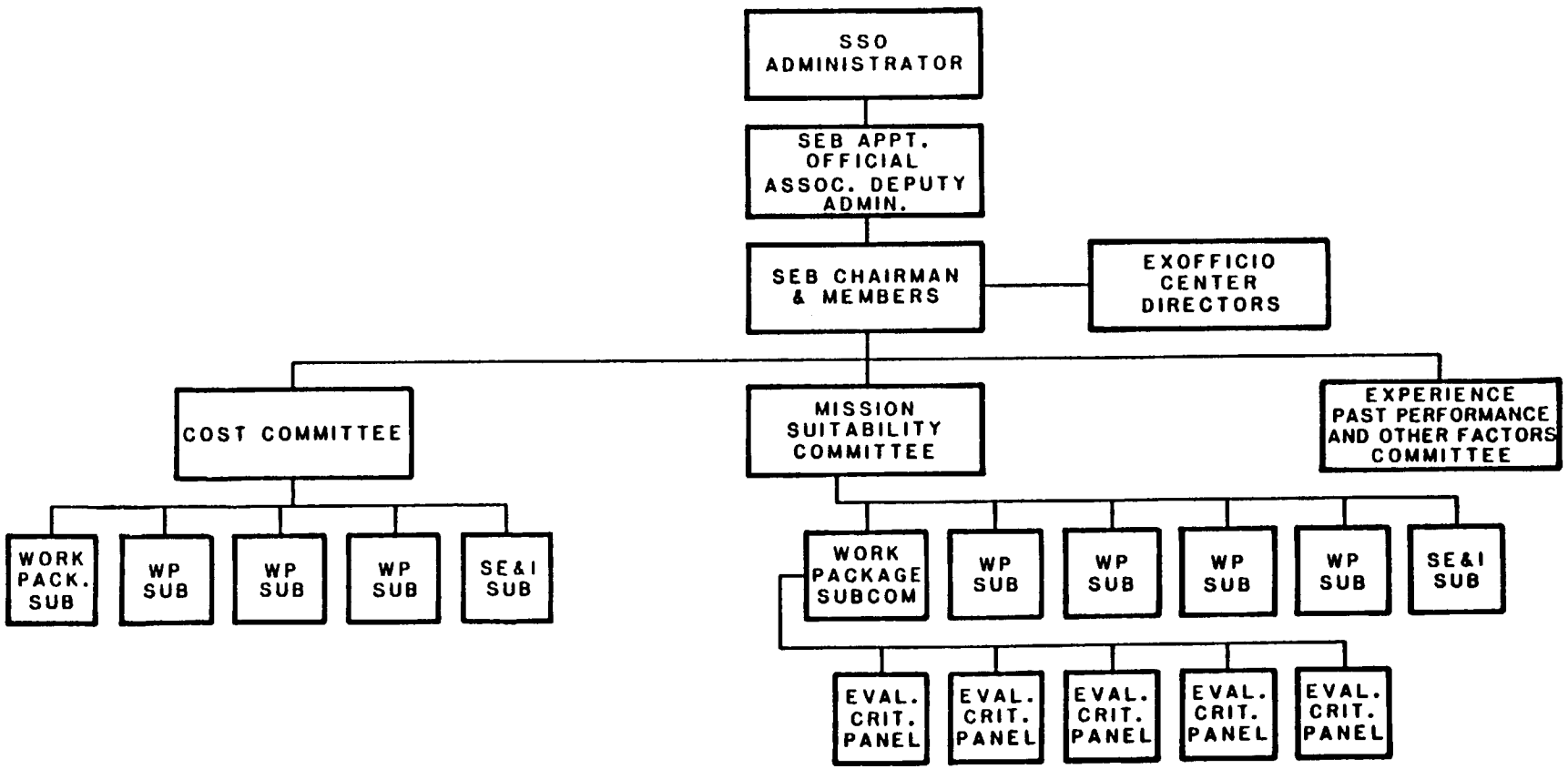
At the base of the pyramid were the technical integration panels, as we noted in chapter 7. Based on the Space Station Management Workshop's recommendations, both disciplinary and cross-cutting panels were employed. Most of the cross-cutting panels were chaired by members of the Level B SE&I organization.[17]

Above the technical panels in the pyramidal structure lay the System Integration Board (SIB), and three key panels: operations, customer integration, and international technical and integration. These three sought to ensure optimization of the configuration of the space station within the evolving requirements of operations, user needs, and the international partners. The SIB was perhaps the single point in the engineering organization empowered to optimize space station configuration within the set of requirements provided by the three panels. Although the three panels and the SIB were hierarchically alike, in the definition phase the SIB's role was more significant than that of the panels.[18]

The original design and intent of these panels and boards was to balance out the differing priorities established at the work package level and to bring them together to fulfill the system requirements. The coordination mechanisms ensured checks and balances. Aaron explained:

> The resources that we brought on board in the form of contractors actually worked for the project managers at the field centers. ... For example, the data processing resource belonged to Clarke Covington; that meant he was the administrator of that contract. It's obvious that data processing affects all elements of the space station in terms of how do you define the architecture of the services, where you put the computer, where you put the CRTs, what's their functionality. All these questions are global kinds of questions, and you get into trouble if he [Clarke] asks the global view of that from the perspective of a single work package. ... If you asked a data processing guy his view of the space station, then he saw it through the eyes of a computer. If you ask a power system guy his view of space station, it is through the eyes of guys who work with solar panels and power systems. ... The question is how you keep all those checks and balances going.[19]

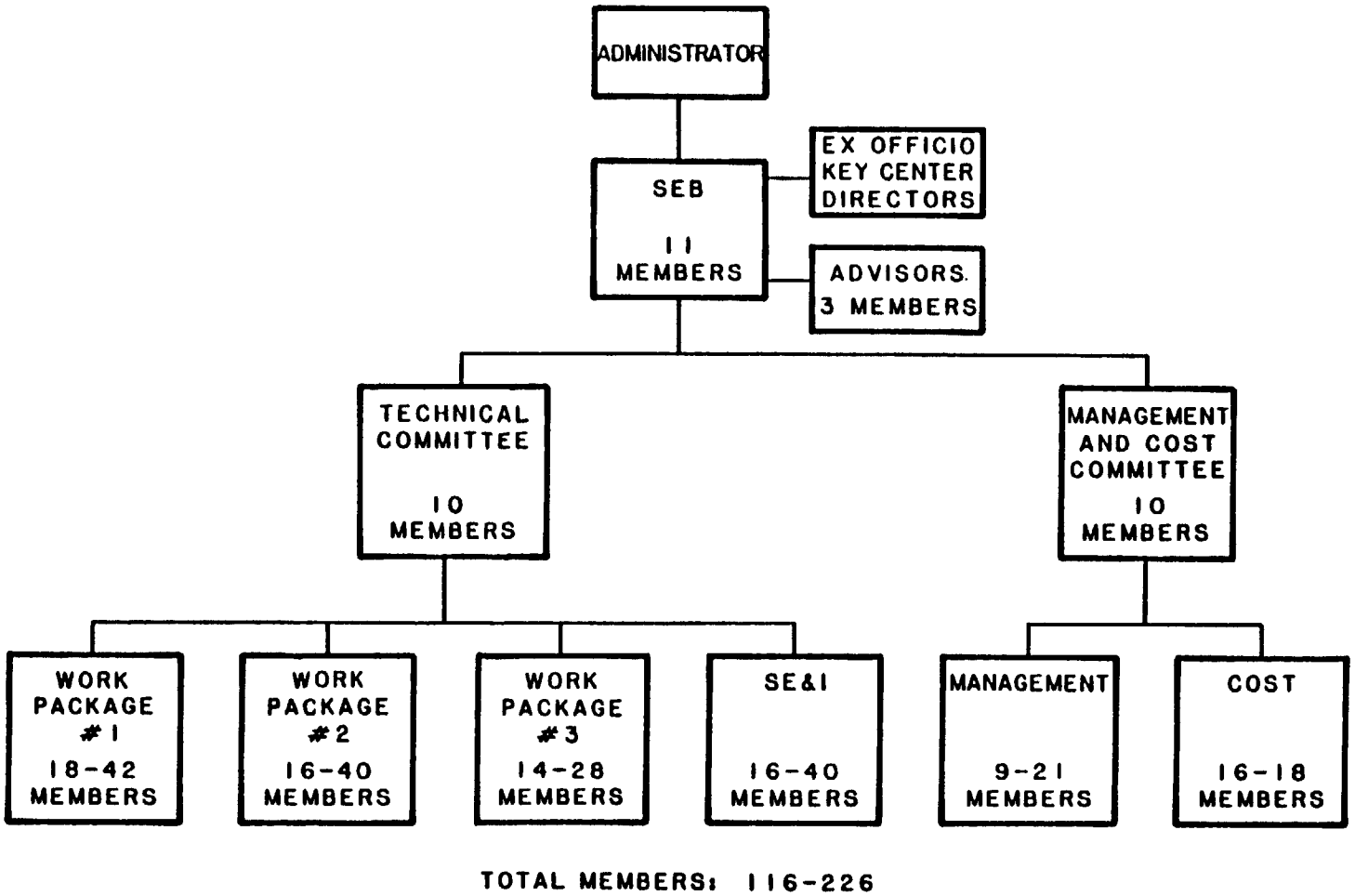
DEFINITION PHASE SEB STRUCTURE



Source: Space Station Program Planning SE&I--Definition/Design, 11/21/83

Figure 5

ILLUSTRATIVE ELEMENT APPROACH
"CENTRALIZED PROCUREMENT"



Source: Space Station Program Planning SE&I--Definition/Design, 11/21/83

Figure 6

The job of the integration panels was to make sure that the trade and engineering studies conducted by the contractors took into account the global question of what the space station requirements should be, not just from the point of view of one center.

The panels exchanged data important in coordination, but they were not empowered to make decisions. The decision-making body in the Space Station Program Office consisted of a control board, which was known as the Space Station Control Board (SSCB).[20]

Staffing

Once Hutchinson and Aaron assumed command of the Level B organization during the skunk works, they faced the problem of staffing. They had to pick individuals to head the respective line organizations and the staff functions. Hutchinson and Griffin negotiated these staffing choices. Since Johnson was the lead center, the managers of the Level B offices also came from Johnson. They were, respectively, Al Louviere for the SE&I Office; Richard Thorson (who was RFP manager during skunk works) for the data management and operations office; Carl B. Shelley for the customer integration office; and Thomas Kloves for the program management office. Gene Rice headed the international office, and John E. Cools led the TMIS integration office.[21]

Most of those chosen for these positions had one thing in common. They had not been associated with the Space Station Task Force. In reality, few people from Johnson who had worked on the Space Station Task Force or the Concept Development Group had responsibility for any of the major offices within the Space Station Program Office. Johnson personnel noticed this, and they did not understand. Not privy to the negotiations between Hutchinson and Griffin, many at Johnson came to believe that Hutchinson brought in people, mainly from flight operations, to serve as key personnel, and people who had key jobs in the task force were not even considered. This meant, to some, that Hutchinson chose to go back to his friends in flight operations. Once it was perceived that this was going on, many people who had worked on the task force decided not to stay with the program office.[22]

The size of the staff that Hutchinson and Aaron had considered also created difficulties at Johnson. Hodge's original estimate for the program office was nearly 200. Hutchinson took that seriously, even though this was a huge number for a program office when compared to the number of people in the program office of the shuttle. Hutchinson also discarded the alternative preferred by the Space Station Management Workshop (i.e., fully matrixed with the Johnson institution) partly as a result of his own (and headquarters') desire to create an autonomous Level B organization. To add to these difficulties, many at Johnson underestimated the complicated SE&I job required for the space station. Their own shuttle experience was different because most of the systems engineering job had been done by the shuttle prime contractor.

At the Langley meeting in September 1983, the center directors had agreed that the requisite SE&I personnel would be provided to Johnson, and, in general, the staffing could be met by all the field centers involved. However, when Level B was organized for the Phase B studies, most of the centers declined to send a sufficient number of SE&I personnel. Johnson people started calling the other centers asking for additional personnel, but most of the centers refused the request. This was a major turning point in the formation of Level B.[23] According to James Kingsbury, the animosities really started to build at that point. Because other centers had refused to send more personnel, the staffing had to be completed with Johnson personnel. There were a few from headquarters, a few from the other centers, but by and large, everybody else from the skunk works had returned to their centers.[24] In addition, it

was also becoming evident that the early estimates of the SE&I task had been understated, perhaps because the center directors did not appreciate the complexities involved. Even at Johnson, which had the lead center assignment and the program office, Hutchinson's estimates of SE&I personnel required were considered to be too high,[25] indicating once again that there was no real grasp of the SE&I job to be done.

Fortunately, Hutchinson had a powerful ally in Griffin, who was able to persuade individuals like Carl Shelley, who was initially resistant, to join the Space Station Program Office.[26] In spite of Griffin's efforts, however, staffing was not easy. Since Johnson had the lead center assignment as well as a work package, both Level B and Level C offices had to be staffed. Clarke Covington would head up the Johnson Projects Office, and when Hutchinson and Aaron sought people to fill the Level B organization, they found themselves competing with Covington. The program organization consumed more human resources that had been expected, so this brought the two offices into combat many times, both wanting the same person to work in their office. One of the tactics Level B used was to offer promotions, which Level C was not able to do at that time. This caused a lot of frustrations in staffing Level C, although promotions were eventually given in Level C as well.[27] There were some individuals who chose to join Level C rather than the program office. For example, Bob Dotts, who enjoyed his previous technical management assignment and wanted to be closer to hardware design, joined the Projects Office, and so did Jerry Craig.[28]

The pattern of recruitment generated different perceptions in other centers. The fact that most of the major offices within the program office were headed by Johnson people was not unnoticed. Even the panels were headed mostly by individuals drawn from Johnson. The other centers believed that they had given up detailees to work at the program office at Johnson. They did not understand why their people had no significant positions within the program organization.[29]

There is one set of staffing decisions that did not involve Hutchinson. The center directors selected the project officers in the four work package centers.[30] Ron Browning at Goddard, Ron Thomas at Lewis, Luther Powell at Marshall, and Clarke Covington at Johnson were chosen to be the project officers. It was unclear why Hutchinson did not show any interest in these decisions. If the program organization was responsible for coordinating the work packages of the four centers, why did the program manager not get involved in the selection of the project officers? In this instance, the center directors made these decisions, checking first with Culbertson, but without consulting the program manager. By not participating in the selection of the project officers at the centers, Hutchinson missed a chance to strengthen Level B and its relationship to the centers.

Budgetary Issues

Along with staffing, Aaron, the deputy program manager, was also involved in outlining the station's resource control requirements. The framework that initially emerged specified the discretion that had been delegated to the project offices. Although all allocations had to be recorded at the project offices, funds could be reallocated at their discretion for focused technology within disciplines. Beyond these discretionary allocations, however, Level C offices could not reallocate funds between disciplines without the notification or concurrence of the program office. They also had to have approval from the program office for funds to initiate new tasks.[31]

Although the framework might appear rational to individuals involved in Level B, the budgetary relationships were somewhat skewed. The program office under Hutchinson reported to Griffin, the center director. At the same time the Johnson project office also reported to Griffin. Theoretically, most of the project offices were under the budgetary control of the program office. Most of the project officers realized that when the program manager had budgetary authority, and he reported to a center director, then they had to rely on the program office for their budget approval. This meant that each of the work package centers (other than Johnson) in a sense reported to Griffin. In terms of his budgetary allocations, Hutchinson was perceived as skewing allocations in the direction of Johnson. Kingsbury remembered that "there was almost nothing that Johnson wanted to do that wasn't supported."[32]

The complexity of all these organizational issues was not lost on the associate administrator for the space station program. Culbertson and Aaron visited Peter M. Drucker, the noted management consultant, on January 10, 1985. They talked to him about some of the organizational issues that kept cropping up in the program organization. According to Culbertson, Drucker emphasized three points. First, the program organization had to change over the phases: before definition, during definition, and then again during Phases C and D. Second, Level B had to be strong in order for the program office to function. And third, the program personnel had a conflict of interest between their career interests and the interests of the program. This confirmed Culbertson's earlier position, namely to strengthen Level B. In addition, Drucker emphasized the need for building good relationships throughout the program by bringing the center directors into this process early.[33]

Project Offices Gear Up for Phase B

The project offices at the field centers were organized at the same time as Level B. In Marshall and Johnson the pattern of organization conformed to tradition. In Marshall, the space station activity moved out of the advanced development programs office into the permanent project office, reporting to the center director. Luther Powell, who had extensive experience in the Spacelab program and who had headed the CDG effort, was appointed the project officer by Bill Lucas, the center director. At Johnson, the informal projects office was formalized, and Clarke Covington, the project officer, reported to the center director. In both Marshall and Johnson, the project offices were matrixed to the institution, consistent with existing NASA practice.[34]

In Goddard and Lewis, who had not participated in a program organized under the lead center concept, the story was different. At Goddard, which had a smaller share of the space station project than either Marshall or Johnson, Noel Hinners, the center director, did not want the work package to siphon off resources from the center. Therefore, he did not let the project organization report to him, but rather to Bill Keithley, the flight project Officer. Ron Browning, a veteran project manager, was chosen to head the project office there.[35] At Lewis, Andrew Stofan created perhaps the only self-contained project office among the work package centers. Ron Thomas was appointed the project officer, and reported to the center director. Further, Thomas interfaced with Hutchinson, letting his deputy, Thomas Cochrane, take charge of Lewis' internal project management.[36] This was unlike Goddard, where Browning managed internal affairs and sent others to interact with Level B.

In addition to the above work package centers, there were project offices at the Langley and Kennedy centers. Langley supported Level B at Houston in major technology decisions.[37] As we have

pointed out in our discussion of the initial work package splits, Kennedy's role in the space station during launch and operations had already been anticipated.

By the time the space station organization was complete and the Phase B studies were ready to begin, one consistent theme dominated the program's staffing. At headquarters individuals who had limited program experience held most of the senior positions. At the program office level, the key positions were filled by "self-styled rookies," and most of the major functions were headed by people who had had little or no involvement with the Space Station Task Force.[38] The project offices were also led by individuals who had limited project experience. Only Ron Browning of Goddard had managed projects. In a major agency-wide program which was expected to transform the agency, individuals with relatively little program management experience led the organization. The relative youth (by NASA standards) of key players did conform to Beggs' desire to revitalize the scientific and technical expertise of the agency. This meant, however, that these people were in on-the-job training rather than being able to handle the problems that came along with knowledge and assurance that comes only with experience.

Bringing the Contractors on Board

NASA does not manufacture hardware or components. It relies on industrial contractors, mostly aerospace firms, for its hardware development. Thus, a substantial element of program management effort is devoted to managing the contractors. Procurement, or contract management, involves a number of time consuming activities: writing a reasonably detailed statement of work, or RFP, which forms the basis of contract awards; evaluating the bids put out by the competing contractors; awarding the contracts; and, finally, managing the contractors as the work progresses.[39]

Traditionally NASA has used the definition process to start with a number of contractors, progressively narrowing down to one development contractor. In the detailed definition phase NASA typically carried two contractors. This, to some extent, encouraged competition among the contractors, since one of the Phase B contractors would be awarded the more lucrative Phase C and D contracts.[40] NASA believes that competition stimulates contractors to innovate, which leads to improved designs during Phases C and D. Further, the expectation during Phase B activity is that the contractors will look for ways that they can be more competitive in their bids during Phases C and D.

Historically NASA has used a number of organizational mechanisms to perform various activities involved in the procurement. For writing the RFPs, NASA organizes a procurement development team to draft the procurement package. The first draft of the procurement package consists not only of the basic requirements but a lot of contractual aspects. The documents are long, including requirements for delivery, actual development of hardware, and a number of data requirements.[41] Developing the procurement package is a very expensive effort and it involves many man hours.

Once the RFPs go out and the contractor bids come in, NASA uses an SEB to evaluate the bids.[42] This is an ad hoc organization that exists only for the evaluation of a particular procurement. The members of the board are senior people, many of who have served on the procurement development team. If RFPs are issued by a field center, the SEBs are established locally: the center director typically appoints the chairman of the SEB. With the concurrence of the director, the chairman of the SEB invites people to serve on the board. While the contractor bids are evaluated, the members of the SEB are cloistered together, insulated from the rest of the organization and the contractors. In NASA, membership of the SEB is tightly-held information, not released to others. As Max Egert put it, "You'd

have to give a million dollars to find out who is on the Source Evaluation Board."[43] This is a legal necessity, and is not politically motivated. The contractor awards have to be fair and be seen as fair, so it is necessary to insulate the members of the SEB from the influences of contractors who have their own self-interest at heart.

The SEB reports its evaluation to the selection process, without making a recommendation, and the awards are made final with the signature of the administrator in Washington. Once the awards are made, the management of the contractors typically falls into the hands of the center or the project office that leads the particular procurement package. As Culbertson noted, "Work package management and managing of the contractors is really a Level C activity. In other words, this has to be done by the field centers."[44]

The procurement activity during Phase B of the space station program retained many of the characteristics of NASA's traditional procurement policy. However, space station had unique characteristics.

Space Station Phase B RFPs

The Space Station Management Workshop at the Lunar Planetary Institute had advanced three options for managing the procurement activity, ranging from a single RFP to more distributed RFPs operating out of the centers. As the skunk works began to write an RFP, it had already been decided by headquarters that there would only be one RFP.[45] To many in NASA, the idea of a single RFP for a multiple procurement was new. As Bob Dotts recalls,

> It was the first time I'd ever seen something like that. It was a generic RFP that then had pieces, and one of the difficulties in building that RFP was to make it clear if you're bidding on Work Package 2, what parts of it do you bid. So what we tried to shred out is to show exactly what the Work Package 2 responsibilities are, but put it together in an end to end document for the total system.[46]

By late June 1984, the skunk works had produced the "Space Station Definition and Preliminary Design Request for Proposals," which was distributed to NASA headquarters and to the centers. Comments were to be incorporated into the next RFP draft, which was, in turn, to be submitted to the Source Evaluation Board. The board would review this draft before releasing it to industry.

The RFP produced intense activity for the skunk works. Hutchinson wrote:

> As most of you are probably becoming aware, I seldom pass out 'attaboys,' but I believe the release of the Phase B RFP for agency review represents a significant milestone in your efforts and definitely warrants one. This group of people, and particularly the leaders, who spent so many nights and weekends browbeating each other and the document into shape, is as fine a team as I have ever been on--and I have been on a few. I only wish there was some way we could keep the whole bunch together for the duration![47]

Although the preliminary draft was available as early as June 1984, the RFP did not go out to prospective bidders until September of the same year. A number of factors may account for this delay. First, the work package issue was being settled during this period. Second, in headquarters the interface mechanisms between the Space Station Program Office and OSSA were being worked out. Burt Edelson, AA for OSSA, was concerned that the user requirements were not adequately represented on the RFP and wanted to meet with individual contractors who were going to bid for the work package out of Goddard.[48] As it turned out, this did not happen. Culbertson made it very clear to the other

associate administrators that the procurement process was to be managed out of the field centers and the Space Station Program Office. There would be time later for Dr. Edelson to express his opinion.

The general public was first introduced to the Phase B RFPs early in July. This was the first time contractors had seen the reference configuration for the space station, called the power tower.[49] The space station reference configuration description, released by Johnson in August, included comprehensive information on design, dimensions, and engineering details. Space station definition and the preliminary design RFP was finally released on September 14th. Bids were due the following month.

The RFP that evolved from the skunk works featured mission-related characteristics, evolutionary growth, customer interface, maintainability, commonality, and test and verification on orbit. A budget of approximately $8 billion had been estimated to define, design, develop, test, and assemble the initial capability. The RFP emphasized the need to contain costs and accommodate international partners. In addition, consistent with the mandate from the House Appropriations Committee, the contracts emphasized the need to study a man-tended option and to incorporate automation and robotics advanced technologies in the design of the space station. The proposals were on a fixed-price basis.[50]

The procurement approach also featured the four work packages. The RFPs summarized the roles to be played by Marshall, Johnson, Goddard, and Lewis. The statement of work showed the preliminary work breakdown structure across the field centers and the role of the Space Station Program Office. The initial plan for Phase B definition was included.

Structure of the SEB

Consistent with the idea of a single RFP, there was a single SEB, chaired by Hutchinson. While the RFP was being prepared, Hutchinson put his SEB together. He chose Aaron Cohen to be his vice-chair. There were representatives from each of the work packages: Luther Powell from Marshall, Clarke Covington from Johnson, Ken Sizemore from Goddard, and Ron Thomas from Lewis. There was also a representative from Kennedy.

Hutchinson's SEB was supported by satellite boards in each of the work package field centers. They reviewed the evaluation plan for each of the work package contracts before the RFPs went out on the street. After each work package team put the details together for the proposal, the board reviewed them and got the SEB's approval. The SEB was ultimately charged with reviewing each of the work packages.[51]

Although there were differences in terms of how the satellite boards reviewed the work of a proposal, the case of JSC was typical. The satellite board at Johnson was organized into two committees, consistent with standard NASA practice: a technical committee and a management committee.[52] The technical committee consisted of engineering, advanced development, and customer utilization panels. The management committee evaluated the management capabilities of the proposers, including the cost reviews.

With approximately $155 million in space station definition contracts to be awarded by April 1, 1985, more than 100 companies teamed up on 13 bids received by NASA.[53] As the bids came in, the SEB became active and worked at a hectic pace from the third week of November to the end of December. Each of the source boards from the work package centers sequestered off in buildings to evaluate their respective bids. Each reviewed their findings with Hutchinson's SEB on their particular date. The main source board read all the proposals and reviews of the satellite boards to make their final judgments.

The final decisions would be made by Beggs himself, so the evaluations of Hutchinson's SEB were submitted to headquarters. By March 1985, NASA announced the successful Phase B contractor teams.[54] The winners at Marshall were Boeing and Martin Marietta, successful bidders at Goddard were RCA and General Electric, and the Lewis package went to Rocketdyne and TRW. There was a glitch in the process, however. NASA could not decide the contractors for the JSC work package. According to *Aviation Week*, the proposals from Lockheed, McDonnell-Douglas, and Rockwell "proved too close to call," and required further consideration by the SEB before the final awards could be made.[55]

Johnson's satellite board reviewed the major weaknesses of each of the three proposals with Hutchinson's SEB. Having done that, they developed a set of questions to be asked each proposer which were intended to clarify points that were in doubt. Each prospective contractor was invited to respond to the questions that had been raised. The day for each was decided by drawing straws. On their assigned day Rockwell, McDonnell-Douglas, and Lockheed, responded. The process was repeated several times: the SEB asked more questions, and the contractors returned with their responses. Finally, the SEB had sufficient data to send back to Beggs for his selection. The contracts were finally awarded to McDonnell-Douglas and Rockwell. Lockheed later teamed up with McDonnell-Douglas on its work package contract.[56]

By April 15, NASA had completed a review of the bidders of the work packages. The eight contractor teams who were going to be part of the work packages were on board. The Phase B studies were ready to begin.

CHAPTER 10

PHASE B STUDIES

In April 1985 the space station program launched the Phase B studies. By then headquarters, the program office at Houston, and the project offices at the field centers were ready to go. The contractors were also on board at each of the work package centers.

In order to fully understand the Phase B studies for the space station program, it is necessary to set the context in which those studies took place. First, and perhaps most importantly, Hans Mark, the deputy administrator who had played a key role in the program's approval, left NASA in September of 1984 to assume the Chancellorship of the University of Texas at Austin.[1] As a result, James Beggs was without a deputy as the Phase B studies began. A considerable time elapsed before a new deputy was named, so Beggs relied on Phil Culbertson, the associate administrator for the space station program, to fulfill some of his deputy's functions. This put Culbertson in a difficult position. These duties pulled Culbertson's attention away from the space station program and the other NASA programs in which he was involved. Beggs was aware of this.

> Well, Phil couldn't perforce be the deputy without being the deputy. And you can't occupy a role without having the trappings of the office. He couldn't really sit there and tell center directors to do things because if they want to do it differently, they would challenge his decisions. Does that come from Beggs or is that something you want to do?[2]

Second, the shuttle project—NASA's major manned venture—was experiencing difficulties. Since the shuttle was in the operations stage, it had high public, congressional, and media visibility. Problems with the shuttle consumed headquarters' attention because they had to be resolved quickly. These difficulties also needed the attention of Marshall and Johnson, who between them had the primary responsibility for the space station program. As headquarters and the development centers focused more and more on the shuttle, the space station program did not receive the degree of support that it needed.[3]

Program-related factors also affected the Phase B studies. As noted earlier, the work packages contained overlaps and redundancies. This caused the project offices and their associated contractors to be unsure of their responsibilities. Since resources were closely tied to the content of the work packages, the field centers promoted their own best interests and their preferred options. Thus the program office (Level B) had to arbitrate technical and work allocation disputes among the project offices, a large and sometimes intense task. Second, the program office did not have a staff sufficient for the SE&I task that was so crucial for the coordination of work among the project offices. As we have seen earlier, the field centers could not provide enough personnel to staff the systems engineering function when Level B was formed. Even in Johnson Space Center, the lead center, the institution seemed to resist allocating systems engineering talent to the space station program. In the case of Johnson, this appeared to be because energies were focused on the shuttle project. Third, to complicate matters further, the interfaces among Levels A, B, and C had not been clearly defined, and the process by which such interfaces were negotiated had not really been completed. As a result of all these factors, the Level B organization at Johnson was working under very difficult circumstances at the start of the Phase B studies.

When the lead center decision was made, and the work package allocations were negotiated, no one could have foreseen the departure of the deputy administrator nor the vast attention that the shuttle

would require. Nevertheless, management decisions, especially those of the lead center and the work packages, had determined the course of the Phase B studies and the functioning of the program office at Houston.

Going into the Phase B studies Neil Hutchinson had three major tasks. First, he would oversee a reexamination of the reference configuration, power tower. Upon completion, Phase B would have a preliminary design of the space station that could be taken into the Phase C-D competition among the contractors. His second task was to involve the contractors in the program to a greater extent than they had been before. The contractors would do the technical analysis, prepare the data, and present the changes desired by the work package centers. And his third task was to determine how much the space station would really cost.[4]

In addition to these three tasks, Congress, despite NASA's opposition, mandated two more: studies of man-tended options and automation and robotics.

Three people played important roles during the Phase B studies, dealing with the complex work package structure and NASA's intricate management system. Culbertson led the headquarters office, Griffin was the lead center director, and Hutchinson was program manager. Since Culbertson decided to make Level B as strong as possible, and had therefore delegated a great deal of responsibility to Hutchinson, the program's technical management during the Phase B definition period fell to Hutchinson.

Level B in Operation

As the Phase B studies progressed, Hutchinson's management style became clearly visible.[5] A former JSC flight director, Hutchinson involved himself in the details of his decisions, a process that was interpreted differently throughout the agency. At headquarters, for example, some believed that Hutchinson did not delegate. This then caused a lot of problems for his staff. Because Hutchinson chose to make most of the decisions himself, he weakened a staff that had great potential.[6]

Hutchinson was aware of the headquarters perception, partly because of the conversations he had with Culbertson. "I think Phil felt that maybe I didn't give enough free board sometimes to the Level C guys, and that I overran his guys maybe a little too much sometimes, and I believe that criticism to probably be valid."[7]

At Johnson Space Center Hutchinson was perceived to be a manager who could not distinguish between tasks of differing priorities. Although space station requirements and budget authority, for example, were areas of high priority, Hutchinson is remembered as taking stands on issues such as having a parking place closer to the door so he could devote a few more minutes a day to the program.[8]

And others felt Hutchinson was involved in micromanagement.[9]

Al Louviere, who headed up the SE&I function, remarked, "John Aaron and Neil both tried very hard to convince people that this management scheme we had was very complex, very hard to get anything done in. It was management by committee only."[10] Individuals at Level B who were closest to Hutchinson in the program management, however, described his style favorably. John Cools "felt Neil and John ran an excellent ship. I really do. Neil and John complement each other very well, as did Al Louviere and Tom Kloves, Gene Rice."[11]

What caused such divergent perceptions regarding Hutchinson's management style? To some extent, Hutchinson himself may have contributed to these perceptions. However, there are other reasons for the differing viewpoints.

In the first place, Level B was located at Houston, and this may have exerted an influence on the decision making. Hutchinson got the first taste of the institutional pressure in the first half of Phase B. As we have noted, one of the tasks of the Phase B studies was to reexamine the configuration that the skunk works had produced. During the skunk works, Johnson had advocated the delta configuration for the station. Although the skunk works had eventually settled on the power tower reference configuration, the issue was revisited during Phase B. The proximity of Johnson to Level B allowed some Johnson senior management to insist upon an extensive reevaluation of the delta configuration. According to Hutchinson it was, "a considerably further examination than I guess I thought it warranted."[12]

Although Hutchinson was at Johnson, he had to make every effort to see that the interests of all the work packages were represented in the program. According to Louviere and others, Hutchinson really tried.[13] In his effort to be viewed as independent of JSC pressures, Hutchinson was probably not seen as representative of Johnson's interests.

Second, Hutchinson reported to Griffin, the director at Johnson. So did Clarke Covington, the manager of the Level C work package at Johnson. This meant that Griffin had to arbitrate differences between Level B and Level C. Fortunately for Hutchinson, Griffin had been party to the lead center and work package decisions and was committed to making Level B work. Hutchinson at least felt this was so. "I never had an instance where I did not get the support I needed out of him, either in the management council or downward into the field centers."[14] Covington, the project officer at Johnson, confirmed that Griffin favored most of Level B's decisions.[15]

Unlike Johnson, however, major differences with other project offices could not be resolved so easily. Since they reported to their directors, disagreements had to be negotiated between Hutchinson and the project officers, and between the center directors as well. Thus, the space station program's management system contributed to the cumbersome decision-making process during the Phase B studies.

As we have seen earlier, Level B had panels and boards to resolve technical issues during the Phase B studies. The Space Station Control Board (SSCB), chaired by Hutchinson, was at the apex of the hierarchy of panels and boards. Hutchinson preferred a single decision point, so the panels reporting to the SSCB made recommendations, not decisions. As the issues were worked out in the panels and finally came to the SSCB, all foreseeable implications of the alternatives were considered and discussed.[16]

Although in theory this system worked smoothly, the work package splits and their associated redundancies made it difficult to function in this organization. The major problem was that any of the options suggested by one of the work packages would have to be reexamined by other work packages and their contractors.[17] Since the project officers tried to promote their preferred options, adjudication of technical differences among the work packages became the program manager's major task. According to Hutchinson the division of the space station "brought about a set of management difficulties that were just awesome. It really took a toll to adjudicate the disputes that arose between the field centers over the two years that I was doing it. They were constant, they were difficult, they were sometimes vicious, and most of them were very parochial."[18]

Al Louviere agreed. "[What] most of the centers really objected to was having a Level B override their decisions. ... That really didn't happen, but it was the threat that was there."[19]

Thus, although Culbertson wanted Level B to be strong, and Hutchinson wanted to be perceived as neutral and impartial among the work packages, the management system and the work package overlaps, in addition to Hutchinson's style of management, contributed to lengthy decisions over technical issues.

Level A and B Interfaces

Culbertson also faced a formidable task. He was in charge of the space station program, a program that had been publicized as NASA's next logical step. He represented the space station program in Congress and to the international community, and was in charge of the policy decisions that guided the program and directed the program management to conform to headquarters' guidelines. As the Phase B studies progressed, Beggs' reliance on Culbertson clearly sapped his energies. Culbertson's duties were also complicated by the intricate structure of the space station program.

Administrator Beggs' presence mitigated the ambiguous nature of Culbertson's task somewhat. Having initiated the program, and won its approval from the President, Beggs, the agency's chief executive, was unquestionably committed to the program. Further, Culbertson had Beggs' support and confidence. Much depended on the personal relationships at headquarters, however. The structure of the space station program itself did not vest much authority in the associate administrator for the program. The problem that existed in resolving differences among the work packages (the AA had no direct line to the project offices) also existed when major differences had to be settled among the center directors. In this instance, however, the single point of resolution rested at the administrator's office.

Furthermore, in his desire to make Level B as powerful as possible, Culbertson had delegated most of the budgetary authority to Hutchinson, although Culbertson could override him. This had two major consequences. Hutchinson had the responsibility to make the first-level resource allocation among the work packages. Culbertson then found that in overriding Hutchinson's recommendations he had to violate his basic desire to keep Level B strong. Since Hutchinson reported to the director at Johnson, work-package centers other than Johnson could make a case that Hutchinson skewed the distribution of funds in Johnson's favor.

In addition, as we noted earlier, when the Phase B studies began, the interfaces between Levels A and B had not been worked out. Functionally there were many interfaces: systems engineering and integration, operations, customer utilization, and international participation. At least two of these interfaces appear to have been well managed: customer utilization and international participation. Both functions represented NASA's involvement with its external constituencies. The perception of better management in customer utilization and international participation here is understandable. These were areas that were not a bone of contention between centers, so the decisions regarding these matters were not continually revisited and changed.

Also William Raney and Carl Shelley, the individuals in charge of customer utilization at Level A and Level B respectively, established a good working relationship which enabled Raney to communicate the user requirements (as seen from headquarters) to Shelley. Shelley could represent the user requirements in the space station program management's deliberations. In the case of international participation, headquarters inevitably had to play a major role because these negotiations were considered "exceedingly sensitive."[20] Under Bill Raney's direction, Peggy Finarelli lead the team at headquarters, and Gene Rice represented Level B. In addition, Culbertson chaired a committee of inter-

national partners. Hutchinson was a member, although "during this time the activity in the international world was really steaming up, and Level A was running that activity totally."[21]

Perhaps as a consequence of headquarters' budgetary dependence on the program office at Houston and the lack of clarity in the station's interfaces, Culbertson and Hutchinson became the central figures in managing all the interfaces between headquarters and program management. Headquarters personnel associated with the space station program sometimes felt confused within this organization, and sometimes felt powerless to influence the course of events. Level A's lack of say-so over the budget is an example. Raney commented, for instance, "Those of us who thought that in some sense Level A should be senior to Level B didn't appreciate having Level B decide how much money we were going to have to spend."[22]

In a three-tiered organization structure such as the one NASA had devised for the space station program, the interfaces between Levels A and B were always difficult. In the case of the space station program, these difficulties were exacerbated by two other factors. First, as we have already noted, both Culbertson and Hutchinson had to depend on others to direct and manage. Second, the space station was a relatively new organization. It takes time to build relationships and establish clear interfaces. It would have been unrealistic to expect that complex interfaces could have been worked out rapidly. As the Phase B studies progressed, the intensity of the task may have caused NASA to lose sight of these factors. Structural factors contributing to the frustrations of NASA employees tend not to be personal, and are therefore overlooked or ignored in attempts to vent those frustrations. Culbertson, on the other hand, was visible to those under him, and he became the focus of their complaints.

Issues at Level C

As the Phase B studies moved along, the project officers at the centers felt the impact of Hutchinson's leadership, the structure of the program office at Houston, and the long, complex decision making process.

Johnson Space Center

At Johnson, Hutchinson's effort to build a program office independent of the JSC institution created difficulties for the project office, especially in staffing matters. Since nearly half the Program Office was staffed with Johnson personnel, Johnson's institutional resources were taxed considerably. This meant that Clarke Covington, head of the Johnson project office, had to go head to head with Level B to get the project office staffed. Covington felt that Griffin was supportive of Level C, but in disputes between Levels B and C, he believed that Griffin supported Level B.[23]

Since the work packages contained overlaps, and program management coordinated the work, the division of responsibilities among the work packages and between Levels C and B at Houston was unclear. This meant that at times Level B was doing what should have been Level C or Level D work. The selection of the concept for deployment of the truss and the size of the truss structure for the dual keel is an example of this problem. How should it be directed? Should it be put together from a "bunch of sticks"? Was it deployable, or did it basically deploy itself? What should its size be? As Bob Dotts recalled,

> We were given the responsibility for the truss, that was part of our work package, and so we went off and did a lot of work with our contractor, the different options, trying to look at the cost and so forth, and we came back to the Systems Integration Board that Al Louviere chaired.

> ... We gave a 12-hour presentation to that SIB on the subject, and it showed the minimum cost was to go with an erectable, but we felt the ten foot was the better way to go. All the other work packages agreed with us, that that was the minimum cost. But Al had Langley supporting him in the activity, and his guys didn't agree with that, they felt that the bigger truss had some real advantages, primarily from a customer standpoint and a rigidity standpoint. ... The frustrating thing was they chose to go with the five meter.[24]

The complex committee structure, causing long and arduous decision-making, was also frustrating to those at Johnson Level C. This frustration persisted in spite of the recognition that the Level B program office had a difficult job to do.

Marshall Space Flight Center

Since the memory of work package negotiations was still fresh in the minds of people at Marshall, the project office there was aware of the composition of Level B, especially its committees. Level B personnel dominated the SSCB, which was at the top of the committee structure. Most members of the SSCB were originally from Johnson. Although Hutchinson had tried hard to project his independent image, Marshall continued to believe that Level B was influenced by the JSC institution. This was a difficult perception to refute since the SSCB "had 19 people on it, 16 from Houston [Johnson], 2 from Huntsville [Marshall], and 1 from Goddard."[25] Level B personnel chaired most of the panels reporting to the SSCB as well.

Because of the dominance of Johnson personnel, those at Marshall felt thoroughly underrepresented. This may have been the reason for the SSCB's decline in attendance. Why should Marshall people attend the SSCB when it was a foregone conclusion that their point of view would lose?[26]

Such feelings were exacerbated by the push and pull of the various work packages which lengthened the meetings of the boards and panels far in excess of the four hours scheduled.[27] As far as Marshall's representatives were concerned, the work package at Johnson enjoyed the benefits of proximity to Level B. Since Huntsville was far away, and travel took time, Marshall representatives were not able to attend many of the frequent meetings of the technical panels. The length of these meetings led Luther Powell to write to Hutchinson in protest.

> It is my understanding that several of the technical panels which met the week of March 4-8, 1985, have established follow-on meetings. As you are aware, this is contrary to the agreement reached between Level C centers and Level B.
>
> The amount of activity in the program and the limited manpower available make it difficult, if not impossible, for the centers to continually support these meetings. I, therefore, strongly urge you to inform the panel chairmen that follow-on meetings are not to be planned.[28]

At Marshall, as at headquarters, there was also the perception that Hutchinson did not delegate.[29]

At Johnson, Covington could take his disagreements with Hutchinson directly to Griffin. In the case of a Marshall dispute with Level B, however, Lucas and Griffin had to resolve the issue. Since budgetary authority was vested with the program office in Houston, this did not seem to sit well with Bill Lucas.[30]

Goddard Space Flight Center

Goddard's project office also experienced difficulties with respect to budgetary authority, the time demands of meetings, and the delays in decision-making. Ron Browning at Goddard, perhaps the most experienced of space station project managers, was sensitive to Level B's role, and the fact that the space station program was in its infancy.[31]

Goddard was organized differently from the other centers. Browning reported to Bill Keithley and was, therefore, one level removed from the center director, Noel Hinners. Thus it was widely perceived that he had less access to the center director than the other project officers.

Goddard experienced the same problems with attending meetings as Marshall. Delays because of Hutchinson's insistence on making all the decisions also kept Goddard from moving forward on their work, and this eventually involved the international community as well.[32]

Browning was used to working with projects with good boundaries, ones that were well understood and defined. He found the constant bickering and inefficiently run program to be a product of the manned aspect and not at all like he was used to working with. Eventually interest in the program at Goddard waned somewhat because personnel there saw that it took up a lot of resources and did not really make a lot of progress.[33]

When the work package splits were negotiated, the major linkage between the manned and unmanned elements of the space station program involved commonality. This commonality presented problems for Goddard during the Phase B studies. Goddard's part of the space station was the unmanned, scientific experiments, and free-flying platforms. As Browning said (and Noel Hinners confirmed), "commonality for the sake of commonality put an undue burden on us, in weight, maybe in complexity, possibly even cost."[34]

Goddard was also restrained by decision-making delays. There were two lab modules in the work package splits, one at Goddard, one at Marshall. A lot of time was spent on how to divide up the modules. Part of the delays was attributed to Hutchinson's leadership. "He had never run a project and a program, and that was kind of obvious when you got to watching. He just didn't have the experience base."[35]

Goddard's user's perspective also was not completely appreciated. At times the pressure to build the space station took precedence over the needs of the users. "We felt that what we were bringing to bear was building things that got long-term use, and we had to look at it from that point of view."[36]

Despite the different perspective, Goddard's project office understood Level B's difficult job.

> Because of this approach of multiple centers, I guess Level B also was trying, and I think they did a pretty good job, of trying not to be biased, because there they were in Johnson and a lot of the arguments and fights were between Johnson and Marshall, and they tried to be as neutral as they could be, and it's tough.[37]

Lewis Research Center

The space station program was important for the survival of Lewis as an institution. Andrew Stofan had formulated Lewis Research Center's strategy around the space station program. This was not lost on the project office. Ron Thomas, the Lewis project officer, sought to represent Lewis in a favorable light to Level B. He wanted to establish the credibility of the project office, and show that it could perform developmental work on the station's power system.

Langley Research Center

Although Langley Research Center did not have a work package during the Phase B studies, it performed four functions. Langley supported Level B with SE&I. It was also in charge of the evolution studies, and had some responsibility for advanced development of technology. Langley's advanced development program reported to Mark Nolan, the advanced development manager of Level B at Houston.[38] In light of Langley's supporting role, its stake in the space station program was considerably

less than those of the work package centers. Langley provided a unique vantage point for observing the relationships between Level B and the other centers. "We could see that there was a lot of tension created ... I'm not sure they handled that too well."[39]

There were also differences of opinion between Level B and Langley. Langley had been involved in the VHSIC program, and the military supported the Speed Integrated Circuitry Program. Since the military was involved, product lines were maintained. If, for example, NASA built a processor and ten years later needed it back, the agency could do it. In the case of the shuttle project, Langley had to replace the computers, and since the Westinghouse Corporation no longer maintained that product line, it had turned out to be very expensive. Thus, Langley sought to get the VHSIC into the space station program.

> We felt that was a big plus, going down to Level B to start to get it into the program. And the response down there was, well, we don't really have to do that because, see, we will have these work package contractors, and in the work packages there will be a contractor who is involved in the VHSIC Program, so we'll have it there. That isn't true. You don't get VHSIC just because you have Texas Instruments involved in your program. You get the VHSIC insertion because you are working with the program. That was a false perception, and we never could turn that around.[40]

As a result of these differences, some at Langley perceived Level B to be "close-minded."

* * *

At the project offices, the prolonged meetings necessary for coordinating the work packages were, therefore, viewed with frustration. Inevitably, Level B disagreed with them on several matters. To some extent, all program managers faced tough decisions and could not appease everyone. In the space station program, the program manager's role was rendered more complex by his structural location, the redundancies in the work packages, and the differences in culture between manned and unmanned programs. It was far easier to meld two development centers—Marshall and Johnson—in the shuttle project than four field centers—two of them development centers, one a science center, and a fourth a technology center—in the space station program.

Accomplishments of Level B Under Neil Hutchinson

In spite of structural problems and overlaps in the work packages during the Phase B studies, Hutchinson's program office accomplished a great deal. The program office undertook a careful examination of the station's configuration during the Phase B studies, which resulted in a change of the reference configuration from power tower to dual keel. Many in the space station office considered this change a major victory for the station's users.

The industrial contractors who would eventually be involved in the space station program during Phase C and D were brought on board. The project offices at the various field centers relied on their contractors for many of their studies; the contractors presented their findings to the SSCB and other panels of the program office at Houston. Over time, they made recommendations regarding the reallocation of work packages.

The Space Station Program Office was successful in arriving at a cost estimate for the program, which in Hutchinson's estimation remained valid through Phase B.[41]

The program office accomplished three additional objectives: First, with the passage of time, the four work package project officers built a working relationship that has continued to the present. These relationships provide overall stability for the space station program. Second, more than in any other previous NASA program, the Space Station Program Office emphasized user requirements as the primary driving force for the station's configuration. Thus, one of the Space Station Task Force's major guidelines was upheld during the Phase B studies. Finally, the program office, under Hutchinson, brought ESA, Japan, and Canada into the deliberations regarding the program's technical details. This was the first time that NASA successfully brought international involvement into the definition stage of a program.

In sum, as the Phase B studies under Neil Hutchinson progressed, the space agency revisited several of the problems created by its intricate management system. Much depended on the relationships and understanding between three key individuals in the program: Phil Culbertson, Neil Hutchinson, and Gerry Griffin. To many of the field centers, the experience of working interdependently with other centers was new. The nature of the definition period was such that nothing could be cast in concrete. In addition, the work package issue exacerbated the problem of overlaps and redundancies. This intensified the managers' roles. It is a tribute to Neil Hutchinson's energy that so much was accomplished in so short a time.

PART IV

THE DECISION REVERSAL

CHAPTER 11

TURBULENCE IN THE SPACE STATION PROGRAM

NASA experienced unprecedented and increasing turbulence beginning in 1984, and this influenced the space station program's evolution. Hans Mark's exit in 1984 signaled the beginning of top management turnover within the agency. His departure left James Beggs without a deputy. As we noted in Chapter 10, without Mark, Beggs began to rely heavily on Phil Culbertson, the associate administrator for the space station program, to fill the deputy's role.

Lt. General James Abrahamson, associate administrator for the Office of Space Flight, also left NASA to head up President Reagan's Strategic Defense Initiative, and Jesse Moore took Abrahamson's place. Beggs knew he had placed Culbertson in a delicate position, but finding a replacement for Mark was not easy. "I couldn't get the White House to move. I had a couple of candidates that I said, 'I'll pick one of these,' and they wouldn't do it."[1]

William Graham was the White House's final choice to be NASA's deputy administrator. Unlike Mark, Graham was not familiar with NASA. He had previously worked as a staff analyst, and many felt that he lacked line management experience. NASA personnel quickly noticed the uneasy relationship between Beggs and Graham, especially at headquarters. Beggs was keenly aware of their differences.

> His [Graham's] priorities were quite different from mine. I don't think he could have done much on the shuttle, but he kept it at arm's length. He wasn't interested in getting involved there. He didn't go to the readiness reviews. He didn't get down to the people. He was uncomfortable with it.[2]

As a result, Beggs continued to rely on Culbertson for management issues, particularly those involving the shuttle. Discord in NASA's management ranks climaxed with Beggs' indictment, a terrible morale blow to the agency. It was a sad day for NASA, not just for Jim Beggs, because this was the first time that NASA had been touched by a major scandal. Although Beggs was later vindicated, the damage had been done, both to Beggs and to NASA.

Graham had been at NASA for about ten days when Beggs was indicted. Beggs, of course, took steps to support Graham and in this received help from Culbertson. Culbertson described what happened:

> On the way into work on a Monday morning it was announced on the radio that Mr. Beggs had been indicted. ... I went to my office, and I typed a note myself to Jim Beggs which said something like, Jim, I'm terribly sorry to hear what's happened. If I can be of any help, let me know. And I walked over and gave it to his secretary before 8 o'clock, and then I went back to work. He called me out of a meeting that was going on at 11 o'clock and asked me to come to his office. We met about 11:15 and he asked me if I would move back to the administrator's office to provide some help to the new deputy administrator who was going to have to be acting administrator while Jim was on leave. And I said, I'll do what you want me to do. And so he had Bill Graham come in, and we outlined the job, and gave it a title—general manager. There had not been a general manager for the last 15 years. I wrote the position description, and we wrote another piece of paper appointing John Hodge as acting associate administrator, and I wrote it for Beggs' signature, and Bill Graham said, why don't you write it for my signature and then it will show that it was a decision that all of us made. That was changed, and the job was done.[3]

Culbertson knew that he was in an extremely awkward position because it would be perceived that Beggs had "put his man in to keep his eyes on Bill Graham."[4] Culbertson had developed a close working

relationship with Beggs, and his sense of loyalty forced him to accept a sacrifice: he relinquished the space station program, which he had long cherished, to become NASA's General Manager. "I already owed a lot to Jim Beggs. He had done a lot of things for me, and it seemed to be the thing to do."[5]

This arrangement between Beggs, Graham, and Culbertson did not last long. Soon after the Challenger accident a significant disagreement arose between Graham and Culbertson causing Acting Administrator Graham to revoke all of Culbertson's authorities agreed upon during the earlier meeting with Beggs. Only with the arrival of James C. Fletcher, Beggs' replacement, did Culbertson reemerge with authority.[6]

Fletcher offered Culbertson the leadership of the space station program, but Culbertson declined for two reasons. First, he knew that for the time being he could be more useful in the administrator's office.[7] He also knew that he would not be in charge when the station was launched, which had been his dream, and that fact led him away from the program.[8] It was with sadness, therefore, that Culbertson handed over the leadership of the program to John Hodge.

Beggs' indictment, his leave of absence and eventual resignation, meant that NASA was without the two top administrators who had orchestrated the successful space station initiative. Leadership of the agency rested with an acting administrator. The turnover at headquarters was also mirrored in the centers. Gerry Griffin left to head the Houston Chamber of Commerce. His departure dealt a severe blow to the space station program because Griffin, who had been intimately involved with the details of the space station program, had understood the guiding principle under which it operated, especially the need for agency-wide involvement. He had created an effective management team on which Neil Hutchinson had relied throughout the rocky Phase B studies period. With Griffin's exit, the leadership of the Johnson Space Center passed to Jesse Moore, who had not been party to the center directors' alliances. In addition, Moore had limited familiarity with Johnson at the time he became director, having served his major NASA tenure with the Jet Propulsion Laboratory. As a newcomer to Johnson, Moore needed time to bring others around to understand his own management style.

A further blow to the program came with the exit of Neil Hutchinson, who had shouldered the tremendous task of program management and had worked what others at Johnson and NASA believed to be an impossible job. With Hutchinson's departure, the two key roles in the space station—associate administrator and program manager—had passed into the hands of acting executives. Hodge was acting associate administrator, and John Aaron, Hutchinson's deputy, became acting program manager.

The Challenger Accident

Turbulence in NASA's management ranks combined with the events surrounding the flight of 51-L, Challenger. The shuttle, a visible symbol of NASA's technological and management excellence, exploded before the eyes of the world on January 28, 1986. The accident dealt a severe blow to NASA morale and the assumptions underlying the agency's management practices. Because of the accident it became obvious to everyone that NASA had problems. Headline hunters and headline writers hammered at the theme that NASA was in crisis.[9] Congress inevitably became involved and authorized former Secretary of State William Rogers to form a commission to look into the Challenger accident.

As a result of the events surrounding Challenger, the shuttle's design was called into question. Perhaps most important, the Rogers Commission questioned the management structure of the shuttle. The management experiment, embodied in the application of the lead center concept, to some extent

was discredited by the Challenger disaster. Of course, by then headquarters' personnel was also becoming convinced that the lead center concept was not working, and that the program management function should be relocated.[10]

Although the groundwork for reexamining the work package decisions for the space station had been laid in September 1985 when Culbertson reopened the work package issue, no decisions were made until months later, after the Challenger accident. Changes at headquarters and at the program level at Johnson meant that key figures who had played significant roles in the management of the space station program were not present when the decisions were made. Of course, John Hodge had been with the program since its beginning, but his status as the program's acting associate administrator did not give him sufficient legitimacy to get everything done. Similarly, John Aaron, the acting program manager, had also been with the program since 1984. But the institutional leadership, Culbertson, Griffin, and Beggs, who had been the primary architects of the space station program, were gone. Moreover, the controversy surrounding Challenger consumed NASA's energy, especially at Johnson and Marshall. With much of the attention focused on the shuttle project, the space station program could not expect the degree of institutional support that it had enjoyed earlier. This lack of support was compounded by the fact that the newer actors' priorities were unclear. Finally, and perhaps as a consequence of the first two factors, the new work package and program management decisions would have to be made in relative isolation from the rest of the agency.

The Transition

With the departure of Hans Mark, Neil Hutchinson, and James Beggs, the stewardship of the space station program passed into the hands of two individuals, John Hodge and John Aaron. Hodge had been deputy to Associate Administrator Phil Culbertson and became acting associate administrator of the space station program at headquarters when Culbertson became general manager. Aaron had served as deputy to Neil Hutchinson and became acting program manager upon Hutchinson's departure.

Consistent with his philosophy of management, Culbertson delegated the responsibility of the space station program at headquarters to John Hodge. When Culbertson became general manager, he chose to strengthen Hodge's position within the organization, just as he had done with Hutchinson.[11] Although Culbertson knew that Hodge's decisions might be perceived to be biased, he did not give much credibility to such perceptions. Culbertson knew that "John understood that he was a controversial figure with respect to his relationship with the Johnson Space Center."[12] Although the detailed definition phase was not over, Culbertson felt that Hodge's conceptual strength would carry the program along. Realistically it would have been difficult for Hodge to act as associate administrator throughout the program, especially during its development phase, but Culbertson felt that Hodge would do a "first class job."[13]

At headquarters the transition from Culbertson to Hodge took place rapidly. Hodge remembered that "it was all a matter of days."[14] Although some decisions of who was in charge of what were finalized later, the pace of the transition reflected the turbulence within NASA at that time.

Hutchinson had left the program office in Houston, but his deputy, John Aaron, provided continuity and stability. In 1984, when Aaron came to the space station program, he had labelled himself a "rookie."[15] Before he became acting program manager, Aaron developed a feel for the program and had now accumulated a fair amount of management experience. He had a established a good working relationship with Level C project managers and enjoyed a great deal of support from Hodge as well.[16]

Hodge brought a sense of urgency to his task. The Phase B process was working, but there was much to do between the date when he took over and March 31st, "which was the decision time for final configuration, final separation of the work packages, final management concept, all those things."[17] And Hodge took his job seriously. "My first principle was, I'm not going to let anybody stop us doing that."[18] Since the turmoil within NASA allowed the space station program to operate in relative isolation, Hodge and Aaron continued their work, for the most part untouched by institutional pressures.[19]

Work Package Splits: Round Two

As we noted earlier, Culbertson's initial work package splits in mid-1984 were made in partial ignorance, since the details of the configuration were not clear at that time, and the station's manufacturing and assembly sequence had not been established. These issues were probed during the Phase B period. Culbertson, Hodge, and the program management were fully aware of the redundancies that existed in the work packages as the Phase B studies had started.[20] They intended to sort them out as they gained a more detailed knowledge of the station. As the studies progressed, the configuration changed from power tower to dual keel and some unanticipated redundancies began to surface during the contractor studies.[21] If redundancies in the modules and the sequence of actual manufacturing and assembly were not sorted out, the contractors could not be specific as to their responsibilities and their accountability could not be established. This could lead to hardware duplication or could create a situation where contractors might blame each other for not fulfilling their part of the bargain, especially in cases where specific work was not accomplished. Assembly sequence created more problems of accountability. The hardware developed by one contractor would have to be transported to another location so that it could be fitted with another contractor's work there. In this scenario hardware might shift contractor hands a number of times, making it difficult to pinpoint where errors or mistakes were made.

As the Phase B studies started in April of 1985, the program management was not sure of the assembly sequence and no one was certain how much redundancy had been built in. Culbertson recalled, "Since the assembly sequence hadn't been worked out, we didn't really know how much was going to be common, and that evolved rather slowly among these contractors as it took place."[22] And as Phase B began to wind down, these redundancies surfaced and had to be dealt with.

An awareness of the redundancies and the problem of accountability was widely shared by members of the space station program at headquarters, program management, and the project offices at the field centers.[23] Anticipating that the decision on the final work package split would have to be made in March of 1986, Culbertson had formed a group to advise him on the matter.

Led by Marc Bensimon,[24] in whom Culbertson had developed a great deal of respect, his advisors consisted primarily of Level A (headquarters) personnel. This working group provided Culbertson with background information regarding the work package decisions that needed to be made before the development contracts were awarded. In a series of sessions, the task group developed a philosophy for work package splits for the development phase. According to the group, the work package decisions for the Phase B period themselves consisted of redundancies: the field centers had bits and pieces of work assigned to them, and there had been no attempt to organize the work into more or less self-contained projects. The division of work packages during Phase B had produced intricate and complex interfaces.

Integration of the work packages—where the interfaces came together—was located primarily at Level B.

The working group thus advocated the idea of "projects."[25] The project concept was anchored in a number of ideas. First, and perhaps obviously, SE&I would be done at the total program level; that is, this function would insure that the whole space station met headquarters' requirements. Second, and perhaps to simplify the SE&I function, the field centers would be allocated relatively self-contained packets of work called projects. The centers could then focus on their work, given the constraints imposed by the SE&I, without undue interference from other work packages. The working group believed that during Phase B such projects could not be designed because each work package had to rely on each other for defining its work. This had prevented them from optimizing their work package because of the multiple interfaces that had been created. For example, guidance control had to rely on data management, which, in turn, was related to many other elements in the program whose work lay scattered across the field centers. Third, projects as envisioned by the working group would be given constraints, guidelines, or ground rules, so that each field center could function more or less independently of the others. Stated differently, each work package project would have to function within envelopes and boundaries laid down by headquarters. This would enable them to optimize their project because the project would be within the established boundaries.[26]

Of course, the experience of Level B in the space station program weighed heavily on the minds of Bensimon's group. The earlier work package decision and Level B's organizational problems had led them to several conclusions. First, because of redundancies and overlapping interfaces, the program came together at one single point in the organization, that is, program management. Second, the staffing for Level B required manpower, which had not been provided to Level B during Phase B. And third, the organization of Level B did not provide adequate controls and levers for managing a program this large.

The working group presented a model against which work package decisions could be evaluated. They were aware that compromises would need to be made before a final division could be made. The model was a first step, providing a yardstick for splitting the work package projects across the field centers.[27] This is the classic way to arrive at work package decisions, so there was nothing unique in this particular approach.

Over a two-month period the working group made recommendations to Culbertson for what came to be known as reslicing the pie.[28] The group stressed that the work package structure should be a central programmatic issue. The issue had to be settled, taking into account key aspects guiding the program, including program factors for the development phase, institutional concerns, political acceptability, and external NASA-related issues. Bensimon's people maintained that the overlap and imprecision in the Phase B RFP no longer served any useful purpose. Furthermore, senior management should clarify the interfaces, particularly with respect to the common modules, and assign unambiguous element and subsystem responsibilities for development and integration. In addition, the group wanted to provide Level B with the authority consistent with the work package structure and eliminate "turf" involvement in data exchanges.[29]

Armed with this information, Culbertson briefed the work package center directors at headquarters. All the centers were involved, but Johnson's position received the most attention. As part of Johnson's presentation, Rockwell, one of the two contractors associated with the Johnson work package, gave its

version of the work package assignments. Rockwell advocated work package splits that gave Johnson Space Center a major role in the space station program, far more than it had received during Phase B.[30]

After Culbertson received the reports from the centers, he sought an independent opinion before deciding the work package splits for Phase C. He invited Johnson's director of engineering and research, Aaron Cohen, to participate in the decision. Cohen gave his report to Culbertson in January 1986 (but prior to the Challenger accident). Although there were differences—some compromises from Johnson's original position had been made—Cohen's presentation was very similar to Rockwell's earlier one.

Bensimon's group and Cohen differed on the solution to the work package splits problem. The Johnson position, as articulated by Cohen, focused on controlling costs by keeping most of the program at one field center. The interfaces in the space station program could be contained in a single work package. This would make the job of program coordination far easier than if it were widely distributed.

Headquarters, however, was committed to maintaining the guiding principles of the space station program that had been formulated during Beggs' tenure. Johnson's recommendation ran counter to two of the program's major precepts, namely that the space station had to be an agency-wide program, and that there should be more than one contractor. If Johnson's division were adopted, both of these principles would have been disregarded. By allocating a major portion of the program to Johnson, the remaining centers, especially Marshall, would have very minor roles. This de facto meant that there would be a single contractor, and it would be associated with Johnson.[31]

Johnson's option did not sit well with officials at headquarters, who opposed it on the grounds that it violated the program's basic premises. Because Rockwell's studies had formed the basis of Johnson's proposal, headquarters took notice. Rockwell, the prime contractor for the shuttle, had considerable experience in major development work. Because of the close relationship between Rockwell and Johnson during shuttle development, headquarters believed that Johnson was "captive of Rockwell."[32]

The work package field center project managers, in conjunction with Level B, deliberated the work package issue. Acting Program Manager John Aaron attempted to build a team to provide stability amid NASA's management turbulence. His group met several times in Memphis, Tennessee. Ernst Geissler, the project officer from Kennedy, was present at some of these meetings, in anticipation of Kennedy's operational role in the future. It was clear that when development work started there would be a fifth work package, managed from Kennedy Space Center.[33]

These meetings also tackled issues involved in managing the program and resolved problems that had developed during the Phase B studies. An effort was made to work out the relationships among the field center project managers and the program manager at Level B. The project manager at Lewis, for example, commented that the sessions went a long way to build rapport among the players,[34] so it appeared that John Aaron's attempts to build a team were succeeding.

Following Cohen's report to Culbertson, headquarters still was unable to resolve the work package splits issue. Under Hodge's direction, headquarters personnel tackled it at the program management level. Bensimon organized a meeting between Levels A, B (John Aaron), and the four work package project officers. Although the process started, headquarters was not fully persuaded that both Level B and work package 2—both located at Johnson Space Center—wanted to play a meaningful role.[35]

A second meeting, lasting two days, took place at the Lunar Planetary Institute in March 1986. All the project managers participated. Marc Bensimon also attended. On the first day it appeared that the project managers arrived at a compromise that most could live with. It centered on the division of work packages during the program's development phase. There was a sense of cohesiveness then, but it fell

apart the next day. The acting program manager and project officer from Johnson Space Center seemed to be reluctant to go along with the agreement. As Ron Thomas recalled, the particular issue of the division of work packages between Marshall and Johnson created a lot of problems. There was no compromise on the part of either to reach a solution.[36]

The meeting at the Lunar Planetary Institute was significant in three respects. First, this was an attempt by program personnel to arrive at a solution to the work package splits. Unlike Culbertson's first decision, no center directors were involved. Second, the reluctance of John Aaron and Clarke Covington to go along with an option where the major work was not done at Johnson was seen as Johnson's institutional position on the matter. The meeting really seemed to epitomize the whole story of the work package wars.[37]

Despite the lack of a resolution, Hodge made work package recommendations to Bill Graham, NASA's acting administrator. Hodge emphasized that a successful program must balance issues unique to the space station program and external issues such as NASA's goals and the talent of the centers. He stressed that the convoluted process leading to the work package decisions had produced two approaches: primary integration and equal accountability. Primary integration hinged on a prime contractor, whereby most of the work would be allocated to one of the centers, presumably Johnson Space Center. The equal accountability approach distributed the work across the field centers and emphasized minimal changes from the existing work package structure. Hodge noted that equal accountability required a strong Level B and created additional integration problems for NASA. He recommended this second option because it meant little change from the existing work package structure, had a broad political constituency, facilitated growth, and utilized NASA talent.[38] In essence, Hodge advocated a position that ran counter to Johnson's proposal. Despite the fact that all recommendations made for final work package splits ran counter to Aaron Cohen's proposal, Johnson continued to advocate the prime contractor option (or non-option, as it was).[39] Even as late as May 1986, for example, internal memos at Johnson indicated that headquarters would adopt the prime contractor option because it was the sensible thing to do.[40]

Many remember the work package splits during 1986 as a struggle between two polar options, one promoting a prime contractor and locating most of the work at Johnson, and the other functioning in a distributed mode, with little change from the previous work package pattern. The process did not converge, in spite of the efforts of the project officers, acting program manager, and even headquarters.

Although Hodge had made his recommendation to Graham, the repercussions of the Challenger accident (in January) created problems for his suggestion.[41] With the demand for changes within NASA following the accident, it did not seem prudent to accept a proposal that advocated little or no changes in the existing work package structure. Hodge's equal accountability option located the pressurized environment at Marshall, the structures and architecture at Johnson, the platforms and servicing at Goddard, the power system at Lewis, and the launch operations at Kennedy. His recommendations were very similar to Culbertson's. The distribution of work between Johnson and Marshall, however, created an interesting paradox: it was based on an inside/outside split for the space station. The pressurized environment and all the inside work would be done at Marshall. The structural architectural option at Johnson meant work on all the program's outside elements would be done at Johnson. However, it also meant that Marshall would have responsibility for a major subsystem, the environmental control life support system (ECLSS), traditionally the forte of Johnson.

Johnson's expertise in ECLSS was built on the fact that it had the major responsibility for the shuttle's manned aspects. The astronaut corps lived in Houston. If Hodge's recommendation was accepted, there was speculation that the astronauts might have to move to Huntsville. This speculation caused a great deal of consternation and unnecessary divisiveness because moving the astronauts was never really considered.[42] In the aftermath of the Challenger incident, the astronauts were not pleased, and they did not let the issue rest.

The Phillips Report

While the work package deliberations took place, NASA reeled from the impact of the Challenger disaster. The Rogers Commission Report did little to restore NASA's image. It underscored the problems of the lead center in the shuttle program and called into question the competence of NASA management. The Rogers Commission wanted headquarters to take tight control and bring the centers under its direction. As a result, headquarters decided to reexamine the management structure of the space station program before it began the more costly design and development phase.[43]

In 1984, when Beggs made the lead center decision, Hodge had believed that the decision stood only for the detailed definition period. He thought that during the design and development phase the lead center concept would be reexamined, and based on the experience of the Phase B definition period, NASA might decide to keep the lead center or drop it. In light of the "work package wars," Hodge recommended that an independent committee be formed to evaluate the existing management structure. His idea was favorably received.[44]

Who would run the committee? Graham suggested General Samuel Phillips, who had directed the Apollo project. Hodge did not object, but pointed out the implication of that choice.

> If you give it to Sam, you can almost guess what your answer is going to be, and it is not what we've got. And I said, if I had chosen Sam Phillips, the agency would have been absolutely convinced that I had made a deal. I said, that's okay. If you want to do that, we'll do that. He said, that's what you ought to do.[45]

So, at Graham's instruction, Hodge invited Phillips to evaluate the program's management structure.[46]

Hiring Sam Phillips did have implications, as Hodge had anticipated, especially since Phillips had worked for NASA during the Apollo days. As we recall, two of the alternatives that the Space Station Task Force had considered for the organization of the program were the Apollo and the shuttle models. The shuttle model involved the lead center concept. On the other hand, during Apollo headquarters exercised the program management function. Many knew about Phillips' prior experience and believed that he preferred program management to rest with headquarters. To some it was a foregone conclusion that the space station program's organization would return to the Apollo model when Phillips' findings were announced.[47] In the centers, especially at Johnson, it was also believed that the Apollo structure would return as a result of Phillips' investigation. Not all field center personnel read this implication, however. James Kingsbury of Marshall noted, for example, that he did not understand why Phillips might suggest the Apollo form of organization for the space station program.[48]

Phillips' study had three major objectives. First, it would review the management structure of the space station program. Second, it would investigate the distribution of work among the field centers. Finally, it would evaluate NASA's plans for in-house systems engineering and integration. To accomplish these goals, Phillips formed a committee of "experienced managers with extensive backgrounds in the aerospace industry and knowledgeable of NASA and how the agency conducts its business."[49]

Phillips' group conducted lengthy interviews at NASA headquarters, the Level B program office, and the five field centers involved in station program development. In each of the centers Phillips' team interviewed the center director, project director, and project office employees. The team also spoke with each of the Phase B contractors.[50]

At headquarters, Phillips' group interviewed several members of the Space Station Task Force. These interviews revealed that NASA's autonomous centers and intercenter competition, its severe fiscal restraints, and its minimal centralized control made it extremely difficult for Level B to work as part of a field center organization. These inevitable conflicts of interest constituted a competitive asymmetry. Level B had access to special program resources that enhanced the lead center's institutional capabilities. Level B also could get information about the internal practices of the other centers, data that those centers could not get about the lead center. In addition, since the center directors reported to their institutional associate administrators at headquarters, a major tool that should have enabled the associate administrator of the space station to direct the program was not available to him. The task force members argued that the lead center concept was not workable. They preferred that the program office be directly responsible to headquarters, rather than report to any of the center directors.[51]

Phillips and his group visited all the centers. Each center presented its version of the space station story. Hodge even had a chance to make his case before Phillips' recommendations went forward, but believes "he didn't change anything as a result of what I said, but at least he told me what was going on."[52]

Phillips presented his findings to Fletcher at a meeting attended by then General Manager Culbertson, Hodge, and members of his own group.[53] He outlined principles to restructure the program, to divide the work packages, and to clarify the role of SE&I. At the end of the presentation, Fletcher accepted Phillips' recommendation as the basis for reorganizing the space station program. This quick decision came as a big surprise to some at the meeting.[54]

Having decided to abandon the lead center concept, Fletcher relayed the news to the center directors and called a meeting the following day. At that meeting Phillips indicated how the space station program would proceed.[55]

Andrew Stofan, the director at Lewis, who later played a key role in the space station program, recalled the report.

> Now, what Sam Phillips gave us was what we gave him. ... Once Sam Phillips came to Lewis, I talked to him, and Noel talked to him, and Dick Smith talked to him. And it turns out that all of us told him exactly the same thing. It isn't working, and you have to take it and set something up in Washington to run it. ... You can't have centers telling other centers what to do. It won't work. And we all came to that, even though we're the ones that said, do it that way in the first place.[56]

Johnson, of course, was an exception.

So, based on the Phillips Report, Fletcher decided to abandon the lead center concept, which had been the root of many problems, especially those between Marshall and Johnson. He also chose Andy Stofan to become the new associate administrator for the space station program. Why was Stofan selected for the job, especially since he was content with his director's job, and was reluctant to take up a new position? Stofan himself does not quite know the reasons.[57]

CHAPTER 12

REORGANIZING THE SPACE STATION PROGRAM

The Phillips Committee's recommendations centered on correcting the management structure and improving the distribution of work among the field centers in order to maintain accountability and to better assure product quality. Regarding the management structure, four major recommendations were made:

> Establish space station program management office at headquarters headed by strong program director;
>
> Provide technical support to that office through the acquisition of a contractor highly competent in system engineering and analysis and who would command the technical respect of the field center personnel;
>
> Establish a branch office at Houston for systems integration; and
>
> Provide line direction of the field center project managers directly from the headquarters program management office.[1]

With respect to the work package issue, the Phillips Committee debated three major alternatives. The committee made its recommendations based on the issue of controlling costs. The committee argued that maintaining contractor accountability was essential to cost control. The program should be segmented into clearly definable, major deliverable items that could be integrated and checked out independently. The entire design and development responsibility for each deliverable item should be assigned to a single contractor. In debating the alternatives, the committee concluded that options other than the one they recommended would cost upwards of $200 to $900 million in total program costs. As a result, the committee recommended the following work package assignments: all pressurized modules, nodes, and tunnels to the Marshall Space Flight Center; the truss and its associated systems to Johnson Space Center; the platforms and servicing facility to the Goddard Space Flight Center; and the power modules and the power management system to Lewis Research Center.[2]

The Phillips recommendations thus gave Marshall the role of single module developer and single module integrator for the program. This could have caused a skill mix within NASA, since much of the skill required for the habitation module rested with Johnson, so the committee recommended that Johnson provide technical direction to the Marshall contractor for the design and development of the manned systems.

When Fletcher decided to discard the lead center concept, Hodge anticipated that the news would have to be communicated to each field center with great care and sensitivity. This was, after all, a major change in the space station program. Unfortunately, Jesse Moore, Johnson's center director, planned to leave NASA and was unable to inform Johnson personnel in a timely manner.[3]

At the time all this was going on, Houston was experiencing an economic downturn, a result of growing problems in the energy industry. If Level B was moved from Houston, many felt that this would create further problems because of layoffs and loss of jobs in the contractor community. So when Fletcher accepted the Phillips Committee recommendations, the Houston congressional delegation became concerned. Stofan got the first taste of his new job.

> I had been back in Washington one week and there was a hearing called on the Hill. Fletcher and I and Sam Phillips were called to the hearing. And the first six people that testified were senators and congressmen. I had never seen that happen in my life in Washington. And they proceeded to tear us to shreds over a 'misunderstanding' about the division of responsibility between Johnson and Marshall. ... I didn't know anything was wrong, not that wrong. Fletcher didn't know anything was that bad either.[4]

NASA almost lost the space station because of the Texas delegation's outcry. Fletcher announced a 90 day "cooling-off period" to put the coalition back and save the program. According to Stofan,

> That was a direct outcome of these earlier decisions that didn't define any interface and kept it all vague. We paid the price for that. ... It was just that Jim and I didn't know what we were getting into, neither one of us. We had no idea when it blew up. We didn't know why, what was going on, we didn't understand what all the big problem was. We found out in a hurry.[5]

At headquarters, it appeared that the Houston delegation's protest had been triggered at least partly by Johnson personnel.[6] If this were true, it violated the basic differentiation of NASA's functions: headquarters should interface with Congress, whereas the field centers were primarily in charge of projects and development work. Amid the outcry of the Challenger disaster, such a violation of responsibilities by individuals not skilled at politics could have had dire consequences for the agency if the perception was found to be based on fact.

As Fletcher and Stofan faced their problems at headquarters, emotions in the centers, especially Johnson and Marshall, also ran high.[7] At Johnson the decision to relocate Level B created insecurities in those associated with program management. Johnson personnel in Level B had worked intensely in program management. The decision could mean they would be taken out of their current assignments and placed in other jobs, perhaps in Johnson, or in the Washington area. In light of NASA's travel restrictions and its civil service codes, this would mean a substantial financial sacrifice.[8] Many were unwilling to move. In addition, given the nature of the work package splits Phillips recommended, both Johnson and Marshall confronted the real possibility that they might lose their unique institutional capabilities. Johnson might lose its expertise in the manned aspects of space programs, especially if ECLSS was located at Marshall. Marshall might lose its expertise in structures and propulsion. These fears heightened the insecurity. The morale at each center hit an all-time low.[9]

Fletcher made a number of visits to each of the centers to placate the institutions. Hostility was evident when he visited Johnson. During his open meeting with Johnson personnel, people expressed their extreme frustration, especially over the relocation of the environmental control and life support systems. No one understood the rationale for the decisions.[10] Fletcher's cooling-off period was politically necessary; it was also needed to restore NASA's morale and to allow time to appease the field centers.

Decision Reversal

Fletcher's decision to relocate the program management at headquarters and his selection of Stofan to be the program's associate administrator inaugurated a new era in the space station program. Abandoning the lead center concept was a decision made on conceptual grounds, perhaps without considering the details of its implementation. In this instance, the need for program integrity overrode institutional concerns. The issues that the center directors had raised at the Langley meeting in 1983 still persisted. How could NASA insulate the program management from the political pressures of the capital? How could the agency bring talent from across the field centers to Washington? Did NASA

managers have sufficient manpower to handle the systems engineering and integration function? What impact did the program have on the resources and skills of the field centers?

The Phillips Report had outlined solutions to only part of these issues and had pointed out the need for contractor support for the SE&I function. Beyond that, the Phillips Committee adopted the recommendations of the Rogers Commission in recommending that program management be relocated at headquarters. The decision was, therefore, anchored in the Apollo concept of organization. The milieu and the experience of the program management had played a role.

We have already alluded to the changed environment in which these decisions were formulated. It was a period of unequaled turbulence for NASA, caused by management changes, both at headquarters and at Johnson, and by the events surrounding Flight 51-L, Challenger. The emotions of NASA personnel had been heightened in the wake of the Challenger accident, management turnover left the program in the hands of acting executives, and at the time the decision was announced, Johnson Space Center was without a designated leader. These factors created a situation which could be described as chaotic at best.

By then, the experience of program management under the lead center concept had sensitized several center directors to the difficulty of building collaborative relationships. Lucas, the center director at Marshall, was always keenly aware of the difficulties with the lead center concept, based not only on his own experience at Marshall, but also on his earlier experiences with the Apollo project. Stofan, the center director at Lewis before he became associate administrator for the space station, and Noel Hinners of Goddard also came to see that the lead center concept just could not work.[11]

In addition to the question of the lead center, the experience of the program management also highlighted staffing problems. The project managers at Wallops in 1983 initially estimated that 600 to 1,000 SE&I personnel would be required. Given the magnitude of the systems engineering task that other programs confronted, this may have seemed to be too high by many in NASA, especially the center directors. If the estimates were correct, where would the talent come from, in light of other programs NASA operated? Was NASA's energy consumed with the space shuttle during 1985? At Johnson, where the program management was located, Neil Hutchinson's program did not rely on the Johnson institution, but rather built its own capabilities.[12] This had taxed JSC's resources, however, and many at JSC did not understand the extent of the SE&I tasks involved. Tom Moser, who became program manager under Stofan, among others noted how much he had underestimated the SE&I task.[13]

In retrospect Beggs underscored the turbulence surrounding the work package issue and the lead center concept in this period.

> The one thing that is terribly distressing to me, and will always be distressing to me, is the fact that I was unable to be there at the time when the agency really needed my leadership, or someone's leadership, the most. That was from that period when I was indicted until really Fletcher got his feet back up on the desk. That was a terrible period for the agency, and I think a lot of the problems that subsequently came to light in space station in particular were due to that interregnum when no one was really exercising any top management supervision. ... I think if someone had jumped in there, had been able to do the day-by-day analysis of what was needed, you would have prevented some of the subsequent turmoil that occurred.[14]

Beggs also recognized the need for a support contractor for systems engineering.

> In my mind I felt sooner or later we'd have to take on a systems contractor, somebody outside who would be able to do the systems design and the system conceptualization activity because, while NASA is pretty good at overseeing work done, complex things, they are not terribly good

> at the detail work, the detailed system analysis, system design work. So I felt that sooner or later we'd take on a systems contractor, but first I wanted to get the thing off the ground.[15]

Beggs had conceived the space station program as evolving over stages, each thread to be woven one step at a time. This was consistent with his philosophy of building the space station by the yard.

The significance of Beggs' assessment needs an additional comment. As we have seen, during the Space Station Task Force's days, headquarters had debated the relative merits of the lead center vis-a-vis the Apollo model of organization. Culbertson had always opted for the lead center concept of management, based on the rationale that the program management should be separated from Washington's pressures. He also felt that it would be easier to find staff at one of the field centers.

Hodge argued for the Apollo model of organization. Although in 1984 Hodge had not succeeded in persuading top management to adopt this option, in 1986 he was the acting associate administrator to whom Culbertson had delegated the responsibility for making that decision. During 1985, when Hutchinson headed Level B at Johnson and Culbertson was the associate administrator, there was an implicit understanding among them and Griffin, Johnson's center director. This coalition fell apart with the departure of Hutchinson and Griffin and Culbertson's assumption of the role of general manager. So, in the period before Fletcher took over, clear leadership was not exercised. The system's centrifugal tendencies exerted themselves. By that time, based on programmatic considerations, and its own difficulties in managing the program, Johnson personnel concluded that the work packages should be designed to place the major part of the work at their center. Some might have interpreted the abandonment of the lead center concept as partly triggered by Johnson's intransigence. It was also interpreted as an exertion of authority by headquarters in the decision process.[16]

Fletcher's decision to abandon the lead center concept was also important in another respect. The process of decision-making was a drastic departure from the way the lead center concept had earlier been orchestrated. Under the initiative of the Space Station Task Force, and in a milieu fostered by Beggs and Culbertson, the lead center concept was arrived at as a result of considerable center director involvement. The logic was that programmatic concerns should be tempered by institutional concerns. Further, if the center directors implemented the program, they thus gained an important voice in the decision-making process. As we have seen during the second round of work package negotiations, the center directors were less involved than during the earlier work package decision. Although the directors participated in the reviews of the work package decisions, they were not co-opted into the decision making. This was mostly done either at the program level or by the program manager in conjunction with the project managers.[17] Further, as the Phillips Committee made its recommendations, Fletcher made the decision himself and communicated his decision to the center directors. He did not involve them in the process. This, therefore, was a departure from Beggs' earlier decision-making style.

Why was the decision made so quickly? Why couldn't it have been postponed until Johnson's leadership was in place? The decision to abandon the lead center had perhaps the most severe repercussions at Johnson Space Center. It created insecurity for a large number of JSC people associated with Level B at Houston. What would they do when the program management was removed from Houston and placed in Washington? NASA had always experienced considerable problems regarding assignments when projects were completed. It was clear that many individuals in Level B had deep roots in Texas, and it was unreasonable to expect all of them to uproot their families and move to Washington. Could this have been anticipated when the decision was made?

Ironically, the absence of a clearly designated leader also left Johnson without an advocate for its position at headquarters. Nowhere, perhaps, was the lack of leadership so keenly felt than in the implementation of the decision to reverse the lead center concept.

Fletcher's decision to adopt Phillips' recommendations inaugurated a new era in the space station program. Andy Stofan had his own set of challenges, and he had to appease the Houston delegation over NASA's decision to relocate the program management. He had to build the headquarters program organization from scratch. He also had to forge linkages with the directors of the field centers in order to get the program moving again. Stofan is remembered as a hero for accomplishing these difficult tasks in his relatively short tenure at NASA.[18] Amid this change in program management, one anchor of stability remained: the project offices at the field centers. The four project managers: Ron Browning at Goddard, Ron Thomas at Lewis, Clarke Covington at Johnson, and Luther Powell at Marshall, did not change. This is yet another indication that the overall influence of the program lay primarily at the field centers.[19]

Amid the turbulence of the period the space station program continued to evolve. The major premises guiding the program, which had been articulated during the days of the Space Station Task Force, had remained intact. It was still to be an agency-wide program, combining both manned and unmanned elements, and ensuring a permanent human presence in space. It would cater to the users' needs by accommodating newer technologies as they evolved, and would involve as many field centers as necessary. James Beggs' dream for the space station program had survived.

> Oh, well, I think NASA will come back strong. I think any new president is going to have to address it. I think the tenor of the times will require it. I think the Russians are going to be doing some very interesting things in space. I think the Europeans and the Japanese will be moving, and I think it will start to become a major issue in this country. ... I think NASA will do very well because it represents a very important piece and part of the country's advanced science and technology activity. Not only that, it puts a halo over all of science and technology.[20]

IN SUMMATION

In 1982 NASA faced seemingly insurmountable odds in its desire to create a space station. Indeed, the program did not yet exist. It was only an initiative set forth by the new administrator, James Beggs, his vision for the future of NASA. From 1982 through 1986 NASA gained approval of the program despite the odds, enlisted the support of those both inside and outside the agency, including the White House and Congress, chose the lead center form of organization for the program, performed detailed definition studies, and arrived at an initial baseline configuration. The program grew from nothing to a full-fledged program in the space of approximately four years. In 1986 NASA changed the organizational structure of the space station program and brought the management to Reston, Virginia, a suburb of Washington, D.C.

The management of these formative years of the space station program may not seem unique at first glance. NASA had risen to many technological and management challenges in the past. It had handled major manned programs before, put men on the moon, and designed and operated the shuttle. And budgets of both the Apollo and shuttle projects had been larger (in inflation-adjusted dollars) than the $8 billion allocated for the space station. There were fewer technological difficulties to deal with than with Apollo or the shuttle, and NASA was familiar with the management of multicenter programs.

Despite all this, NASA confronted many unique challenges with the space station program. First, NASA's management undertook the approval of the program in an environment where many constituencies had an impact on the program, and none could be ignored. Congress, scientists, industrial contractors, and even the astronaut corps had to be considered when making station-related decisions. In a climate of economic austerity, it was difficult to appease all NASA's constituencies.

Second, the space station program extended the mission of the agency. As a permanently manned facility, the space station would make operations a regular activity of the agency, and therefore a mission, the same as research on science and technology. This, in turn, implied that even during the design phase, NASA had to figure out how to make the station flexible enough to accommodate growth beyond its initial operating capability, respond to future technological development, and attend to life-cycle costs in addition to development costs.

Third, the space station program policy guidelines differed in many significant ways from Apollo and the shuttle. It was conceived to be an agency-wide activity, which meant that the field centers had to cooperate to an extent unparalleled in any other manned program. The program was to be responsive to customer requirements and involved non-astronaut personnel. The program also involved international partners in design, development, and operations. Each of these policy guidelines was a significant departure from NASA's previous experience, requiring NASA managers to take on new tasks as the program moved to the detailed definition stage.

Altogether, the unique characteristics of the program represented a departure from generally accepted NASA routines, and key decision-makers were aware of the magnitude of the change demanded by the space station policy guidelines. For Beggs, who represented the institutional perspective, the space station program was a means to revitalize the scientific and technical capabilities of the agency. John Hodge, who had a programmatic orientation, viewed the program as a means to bring about change within NASA.

Systemic change was demanded of NASA during these formative years, especially as the program moved to the detailed definition phase. Studies of change efforts in the private sector and in

bureaucracies show that systemic change is only accomplished over an extended period of time. Against the backdrop of our knowledge of organizational changes, the space station program, nevertheless, demanded that NASA managers learn new ways of doing business in a relatively short time.

The intensity of the management task was further magnified by the turbulence NASA experienced during this period. As the space station program moved to its detailed definition stage, NASA's administrator, deputy administrator, the associate administrator for the space station program, the lead center director, and the Level B program manager—the central players in the program—were removed by turnover or reassignment. NASA also experienced turbulence as a result of the problems on the shuttle, which threatened the legitimacy of the entire agency and led to scrutiny of all management processes by the Rogers Commission. The stress and turmoil that followed spilled over to other NASA programs, including the space station.

The space station program was a fledgling program within NASA from 1982 to 1986. Management is both important and difficult during the early stages of a program. The Hearth Committee, which preceded the space station initiative, underscored the importance of management in the early stages when it emphasized that the conduct of the extended definition phase determines the ability to control schedule and cost overruns in major NASA programs. Management is also difficult because new programs tend to suffer from "the liability of newness." Since new programs are not clearly defined, they demand that personnel be flexible and adapt to changing circumstances. (In established programs, organizational structure and individual roles are usually clear, and routine, efficient behavior is possible.) New programs also have a harder time securing resources and are at a basic competitive disadvantage relative to established programs. In the case of the space station, personnel and facilities were not readily available, so established programs had to provide them.

The management history of the period 1982 to 1986 provides four major features in the management of early stages of new NASA programs. First, NASA management showed how difficult it was to establish the legitimacy of a new program, not merely among external constituencies, but internally as well. Second, NASA sought ways to merge programmatic and institutional considerations during planning and implementation. Third, NASA learned that the organization of the program at any given point would be based on the experiences of the previous stages of the program. And finally, a new generation of NASA managers learned about the agency's organizational heritage and the nature of relationships between the centers and headquarters.

Legitimacy of New Programs

In both public and private organizations, major new programs transforming organizational missions are initiated by top management. In NASA, a clear differentiation of functions between headquarters and the field centers has developed over the years, with headquarters initiating new programs and the field centers implementing them.

Generating and maintaining the commitment to new initiatives at the field centers is a sensitive task, since new initiatives compete with ongoing and well established programs for resources and attention. Established programs possess several advantages. They enjoy the patronage of external constituencies. Since they are in advanced stages of technological development, they can point to hardware and equipment as tangible results of performance. Premises (or policy guidelines) underlying these programs have become more or less accepted in the agency, and alternative premises considered in the earlier

stages of programs are typically forgotten. These programs are in the development or operational stages and have been assimilated into the agency's ongoing activities. Major ongoing programs also bring more money to the field centers than newer programs. The design and development phases consume the major share of program budgets, and the established programs can command greater institutional attention at the field centers than do new programs.

The space station initiative did not possess any of the advantages enjoyed by ongoing programs like the shuttle. When James Beggs and Hans Mark decided to launch the initiative, the external constituencies for the space station had to be built with only the promise of future benefits as a drawing card. Consequently, NASA had to create and nurture the legitimacy of the program among those outside the agency as well. By legitimacy we mean convincing others that 1) the program is justified and significant enough to command resources, and 2) the premises or policy guidelines on which the program is based have been understood and the commitment exists to uphold them.

NASA's top management understood the need for creating legitimacy before they could receive Presidential approval and initial congressional funding. As we have seen, a major effort was undertaken to build constituencies: Beggs had established a personal relationship with a receptive President; the task force brought much of NASA into the process and minimized the differences among the centers so that program approval was not jeopardized. Advisory groups allowed external constituencies to have a voice as well.

Headquarters' role in legitimizing the program within NASA was appreciated by both Beggs and Mark. Beggs knew that focusing the agency on a different set of missions would not be easy.[1] Despite his awareness, fiscal austerity demanded that external constituencies be maintained. This led Beggs to an organizational strategy of grafting a major new program onto an existing organization rather than creating a new center. Mark, who had always believed in the lead center form of organization, saw headquarters' job as political, persuading field centers to allocate resources to new initiatives and to conform to policy guidelines without headquarters' involvement in technical management.

The management history of the formative years of the space station program illustrates the complexity of the task of legitimizing the program among constituencies within NASA. Internal problems existed throughout the 1982-86 period. The decision to extend the definition period gave internal forces adequate time and opportunity to attempt to change the program premises they opposed. Many believed that Beggs' plan to build the space station by the yard was not fully understood by Level B personnel as they tackled the cost of the station. Many at Goddard did not appreciate the need for commonality, a technological guideline formulated by headquarters to minimize development costs. Similarly, during the second round of the work package splits, Johnson wanted to change the space station from an agency-wide program to a program that was relatively self-contained within a single field center.

Why did management problems persist? First of all, there was no consensus regarding the priority of premises within the agency. This was particularly pronounced at the field center level, where conflict among premises affected technical decision-making. It became difficult to contain costs with agency-wide involvement, for example, and this was reflected in the difficulty of enforcing technological guidelines such as minimization of life cycle cost and commonality.

Management problems also persisted because the program premises entailed a major change from NASA's normal operating procedures. Over time, as NASA evolved into a decentralized organization, the centers had grown accustomed to autonomy and operating independently of each other in regard to technical management issues. Although fiscal restraints stimulated competition for resources among

the field centers, some top executives considered competition at the technical level not merely a necessity, but a virtue that enhanced programmatic effectiveness.[2] The test bed competition is an example. This built-in competition contrasted with the collaboration required for the space station program to truly be an agency-wide program. The complex technological interdependence among work packages increased the amount of collaboration required.

Because of emphasis on users and the inclusion of international partners, NASA had to change the way it handled its technical activities. Such premises as minimization of life cycle costs forced NASA personnel to adopt new costing techniques. Methods of estimation used in the past that were oriented toward development costs had to be broadened to anticipate costs during operation and growth stages of the space station.

Organizations typically assimilate major operational changes slowly. Maintaining the premises of the space station program, therefore, was a significant management task that could not be accomplished quickly. During the 1982-83 time frame, while the Space Station Task Force was in operation, this task was relatively easy for several reasons. First, both Beggs and Mark, the most powerful executives in the agency, had publicly committed to the initiative and were actively shaping the program's premises. Second, since the task force was mounted from headquarters, Beggs could maintain his priorities. Under his leadership, which we have described as "crescive," individual initiative was encouraged, but when it threatened his priorities it was strongly discouraged. Third, since the approval of the program was a primary task at this stage, the field centers did not anticipate the impact of the program guidelines. Fourth, since the task force was located at headquarters, it was shielded from the field centers' pull toward decentralization. Finally, although the task force drew members from all the field centers, the leadership of the task force managed to keep the members focused on a unified goal, maximizing the flow of information, and freeing the members from field center concerns and generating commitment to the program.

However, from 1984 to 1986, as the space station program moved into the extended definition period, the management task became increasingly complex. Philip Culbertson, as associate administrator at headquarters, discovered that his ability to lead the space station program suffered from the existing structure of centers reporting to associate administrators. No line organization reported to him from the field centers. Similarly, the program manager at Level B had no direct (formal) line of communication to the project offices at the field centers. An organizational structure that facilitated frequent communication was still needed during the extended definition period. The existing structure and the associated work package decisions, however, stifled information transmission. This structure also created extreme dependence on three individuals: Culbertson at headquarters; Neil Hutchinson at the program management level; and Gerry Griffin, the center director at Johnson, to whom Hutchinson reported. In addition, the program had to operate under the premises already formulated by the task force under Beggs' guidance. Since many of the key players, both in program management (including Hutchinson) and at the field center project offices, were not closely associated with the task force, they had little ownership of the process; some did not even appreciate the rationale for the often conflicting set of premises. Finally, unlike the task force, the extended definition demanded a higher level of resource commitment from the field centers. These resources had to come from the centers at the expense of other major programs in advanced stages. Nowhere was this more apparent than in the case of system engineers, a precious resource in NASA.

In a three-tiered organization such as NASA, maintaining program guidelines and channeling resources are significant tasks which are the prime responsibility of headquarters, not technical program management. The decision to adopt an extended definition period implied that the responsibility would be immense during Phase B. As the program grew into Phases C and D, headquarters' role would become easier because more resources would be available for the program and its premises would be more widely accepted in the agency.

Traditional management theory posits that responsibility, influence, and authority should be correlated. There are at least three mechanisms by which such correlation can be maintained: personal (informal) influence, structure, and process of management. As we have noted, Culbertson enjoyed great credibility with Beggs and Mark, the top executives in the agency. This, in turn, lent Culbertson personal influence within NASA. Indeed, he left his imprint on the major program-related decisions: lead center and the initial work package splits. Structurally, the associate administrator of the space station did not have line responsibility over the program management or the institutional heads at the field centers. In large organizations, senior managers exercise influence on the process through their control of milestones, budgets, personnel policies and very infrequently by wielding the weapon of total dissuasion.[3] Culbertson, however, had to rely on persuasion alone to maintain his influence and authority.

The story of the formative years of the space station program illustrates the intensity of the management task required of headquarters in the early phases of the program.[4]

Interdependence Between Program and Institution

In NASA, there is a mutual dependence between the institution and its programs. Major programs such as Apollo and the shuttle are symbols of the agency's success, and provide the rationale for continued agency funding and thus for its survival. At the same time, the institution embarks on such programs only when the top leadership is committed to them. Accordingly, the programs and the institution influence each other.

The influence of programs on the institution is not uniform. For example, the science programs affect mainly Goddard Space Flight Center and the Jet Propulsion Laboratory. Others, such as the shuttle and space station, affect the whole agency. Given the variation in influence of programs on the institution, top leadership may also assign different levels of priority to programs. We see these priorities through the channeling of resources. Typically, given NASA's decentralized structure, headquarters plays a major role in developing and administering the budget while the field centers are responsible for allocating personnel for projects during implementation.

The institutional and programmatic perspectives are different. At its extreme, the institutional perspective holds that programs come and go while the institution remains. From the programmatic perspective the institution exists for the program. The institutional perspective is relatively long-term whereas programs typically are finite. Such differences existed in the space station, for example, between Beggs and Hodge. Beggs saw the space station as a way to build the science and technology capabilities of NASA. For Hodge, the institution served the program.

The two perspectives are often in conflict. From the institutional perspective, resources flowing into the program are a function of the mission and priorities of the agency or the field center. From the programmatic perspective, resources are rarely adequate for maintaining program integrity. Continual negotiation is necessary to mediate between the two points of view.

In single center programs, the differences in programmatic and institutional perspectives are resolved by the field center director. In the traditional matrix of most field centers, the center director is the final arbiter of disputes between the projects officer and the institutional directors. In multicenter programs like the space station, the program structure determines how such conflicts are resolved. In NASA, headquarters may have to make the final decision.

NASA adopted a number of mechanisms during the formative years of the space station program to serve as an interface between the programmatic and institutional perspectives. The agency achieved varying degrees of success. During the task force days, Beggs made sure that the institutional perspective permeated task force deliberations. Key premises—agency-wide involvement, building the station by the yard, no single prime contractor, and international participation—flowed from Beggs' mission of revitalizing the scientific and technological talent within NASA with support of external constituencies. Options which made programmatic sense but which clashed with Beggs' institutional perspective—starting a new center, for example—were ruled out early in the deliberations. Under Hodge, the task force itself became the keeper of program integrity. Location of the task force at headquarters and Hodge's management style facilitated this.

As the prospects for program approval improved, the task force saw the need to invite the institutional leaders into the deliberations. The Wallops and Langley meetings in 1983 were held because the task force believed that if the center directors publicly committed to the details of the program at an early stage, subsequent implementation might be facilitated.

How successful was this process? By one yardstick it was quite successful. The center directors unanimously recommended the lead center organization for the space station program and expressed their preference for Johnson as the lead center. They also agreed to cooperate with each other by providing the lead center with the necessary systems engineering personnel. Later events suggest that the commitment was not firm across the centers. The designated lead center, Johnson, certainly provided the lion's share of personnel resources for the program, much to the chagrin of Gerry Griffin, Johnson's director.

Why was the degree of commitment uneven? Griffin's actions can perhaps be explained. Having persuaded the Johnson institution and lobbied headquarters for the lead center assignment, he staked his professional reputation and credibility on making it work. He also had formal responsibility for the performance of the program manager. This was a personal commitment not merely to the program but to its major premises. It was doubtful that such a commitment could be expected from his successor.

Lewis was different. Stofan assumed the directorship of Lewis with the commitment to reestablish the center. He firmly believed that the space station should figure prominently in Lewis' future. This belief was further strengthened by the strategic planning process he undertook for the center. As a result, both the director and the institution supported the space station because it fit into Lewis' renewed mission.

The center directors at Goddard and Marshall had no personal stake in the matter, and neither institution was dependent on the station for its continued existence. Goddard was in the midst of reformulating its mission and was unclear how the space station fit into that new mission. The

enthusiasm for the space station among the rank and file at Goddard was considerably less than at headquarters. By all accounts, Marshall shunned dependence on any single program, so the institutional stakes in the space station at Marshall were not as pressing as they were for Lewis.[5]

In light of future events, one may ask if the task force's strategy to involve the center directors was effective. How could a strategy based on good intentions yield such mixed results? Why did the center directors' recommendations reflect conditional agreements rather than firm commitments? There are several plausible reasons. First, in NASA, where headquarters promoted competition among the field centers even in the technical arena, it might be unrealistic to expect collaboration to occur naturally.[6] Second, when the field center directors quasi-autonomously set missions for their respective centers (without coordination of inter-center priorities at headquarters), the center priorities may have determined their support for major programs. Third, the primary reason invoked by the center directors in the lead center recommendation was their resistance to headquarters control.[7] This overshadowed the details of implementation, such as how much resources would be actually needed, how much would be shared, and how conflicts would be negotiated. Fourth, when the Langley meeting occurred, several program-related details were unclear: configuration, work packages, and reasonable estimates of personnel requirements. Indeed, many of the center directors had expressed a need to understand the program details when Mark inquired as to the readiness of the field centers to undertake the program. How could center directors engage in rational discussion about implementation when important program details remained unclear? Finally, the short meetings may have precluded careful deliberation. This might have been the case even had the program details been carefully delineated.

During work package deliberations, institutional considerations began to exert considerable influence on program decisions. To a large extent, Culbertson tried to tailor the work packages according to the skill mix available in the four field centers. Headquarters allocated test beds based on its perception of the relative expertise of the centers. Solely from a programmatic perspective, four work packages increased management complexity during the detailed definition period, but since Stofan had made a successful case for Lewis to Beggs and Mark on institutional grounds, Culbertson had to contend with four work packages rather than a smaller number.

In the work package decisions, when distribution of resources among field centers became the focus, active intervention by headquarters was necessary to integrate field center and program considerations. The details of the work package decision created considerable problems in matching work packages to field center skills. For example, allocation of power to Lewis was perceived by Marshall personnel to be at their expense. The center directors attempted to solve the work package problem, but with no success. In the end, Culbertson himself had to recommend work package splits to Beggs, and his recommendations were implemented. Although the initial work package splits in 1984 indicate that Marshall had a skill mix problem (partly created by the earlier test bed assignments), Culbertson's attempt to prevent redistribution of skill mix within NASA only succeeded in increasing the program management complexity.

There was a widespread perception at headquarters that as the space station program moved into the detailed definition period under the lead center form of organization, the institutional considerations at the field centers would begin to dominate the program at the expense of overall programmatic integrity. Some field centers saw Hutchinson as captive of the Johnson institution. On the other hand, Johnson personnel believed Hutchinson deviated from the lead center organization as they knew it from the shuttle program. At headquarters, the ambiguous role of the associate administrator and what many

perceived to be a weakening of the space station organization at headquarters could not prevent the erosion of the integrity of program guidelines.

The revisiting of the work package decisions in 1986, first by Hodge and later by the Phillips Committee, was NASA's response to the need to restore program integrity. During this reexamination, program factors outweighed institutional skill mix considerations in the final recommendations. However, Fletcher's decision to abandon the lead center and realign work packages created problems at Johnson and Marshall. Both centers already suffered from low morale as a result of the Challenger accident. Because of Fletcher's decision Marshall feared it would lose its structural engineering expertise to Johnson, and morale at Marshall hit rock bottom. At Johnson the abandonment of lead center status and its possible loss of environmental controls and life support systems to Marshall resulted in low morale at Johnson as well.

During the period 1982-86, NASA continually struggled with how to negotiate differences between the programmatic and institutional perspectives. Will the differences between program and institution resurface in major new initiatives involving multiple centers? Other things being equal, we think so. The space station story suggests that headquarters will have to act as the final arbiter in multicenter programs; further, since the differences are rarely if ever resolved, headquarters will have to actively intervene in these negotiations.

Evolution of the Program

Programs that involve technological development evolve over distinct phases. This evolution has been observed in public agencies as well as in private enterprises.[8] It is well understood in NASA. These phases are concept development, definition, design, development, launch, and operations. The early phases—concept development, definition, and design—are primarily conceptual tasks and deal with the formulation of the program. Although most of the program budget is devoted to the hardware development phase, the initial phases determine the evolution of the program in terms of both schedule and costs.

Management tasks also vary over the phases. Modern management theory holds that to be effective, organizational forms should adapt to the demands of the tasks and the environment. This idea is not new to NASA. Hans Mark and Arnold Levine, for example, emphasized this in their work on high technology research institutions.[9] In the case of the space station, this idea was reinforced when Philip Culbertson and John Aaron visited with Peter Drucker in early 1985 to discuss the station's management challenges.

Since formulation (giving shape) precedes implementation, contemporary management theory stresses that different forms of organization are necessary during the two stages.[10] Whereas a bureaucratic form of organization is appropriate for implementation, the formulation stage requires the organization design to enhance information flow. This implies that the organizational form should allow individuals to focus on the whole task (not parts of it), encourage open communication (free of status trappings), insure coordination at multiple levels (not at single points in a bureaucracy), and, in general, facilitate operations. Further, the effort required to achieve coordination is greater in the early phases, and bureaucratic mechanisms by themselves are inadequate.

In the years 1982 to 1986, NASA worked to arrive at an appropriate organizational structure for the space station program within the agency. As we have noted, over the years NASA had evolved into a decentralized organization, and the field centers had become more or less autonomous. The institu-

tional forces at the field centers tended to pull the entire organization toward decentralization. Consequently, NASA's leadership sought to balance existing decentralization and demands for coordination in the space station program.

This balance was accomplished with relative ease in the Space Station Task Force organization. The task force was centralized and led from headquarters. The physical separation of the detailees from their respective field centers and the informal structure that John Hodge created allowed the task force to operate smoothly. Further, the personnel requirements did not unduly tax the field centers.

In 1984, after the President approved the space station, NASA embarked upon the extended definition phase of the program. The major management task during this period was to formulate a program which could be implemented during the ensuing design and development phases. Although the task force had begun delineating the program, the extended definition period needed a non-bureaucratic organization. Technical aspects of the program lacked specificity. The program elements were highly interdependent, a fact underscored by various groups that worked on the work package splits. As a result, individual roles within the program could not be delineated. Finally, the program guidelines formulated by the task force were not defined in operational terms because the priorities remained unclear.

The extended definition phase required technical resources that were typically available at the field centers. NASA consequently faced the problem of relocating personnel, and field center personnel stressed the difficulty of technical management at headquarters. Some top executives at headquarters (Hans Mark, for example) and the field center directors believed that the program management would eventually be located at a field center. NASA thus confronted the issue of embedding a program within its decentralized field centers.

Although program proponents stressed the need for strong coordination, NASA management adopted the lead center form of organization and placed the program management (Level B) at Houston. In the process, the program manager was denied formal access to the associate administrator for the space station; further, the project officers who reported to their respective field center directors were also denied formal access to the program manager. A spirit of cooperation among the field centers thus became the primary coordination tool.

The extended definition period dictated two levels of coordination. The first level was between headquarters and program management so that policy guidelines formulated by Beggs and the task force were maintained. The second level was between program management and the project offices so that the interdependent technology of the program elements would be integrated. Coordination problems persisted from 1984 to 1986, the time that the lead center was in effect. Initially, the skunk works held at Houston in 1984 retained many characteristics of the task force. As we had seen, individuals drawn from various field centers came to Houston to work on the skunk works. Since NASA had had previous experience with this type of organization, it was not new to many of those involved. Skunk works itself was organized into working groups, promoting a free flow of information and facilitating coordination of tasks. It was not surprising that most field center personnel had favorable experiences in the skunk works. However, coordination between headquarters and the skunk works may not have taken place at multiple levels. Some associated with the task force believed that skunk works did not take advantage of the concepts developed by the Space Station Task Force or the Concept Development Group. In addition, those associated with the Office of Space Station at headquarters had difficulty getting operational details—some mandated by Congress—into the program.

As the skunk works folded into the program office at Houston, coordination problems intensified at both Level A and Level B. By then the initial work package splits had already been decided. Work packages, by their very nature, emphasized division of work to the detriment of program integration at a time when integration was still extremely important. In the competitive climate of NASA, cooperation among the field centers did not occur automatically. Furthermore, as the Phase B studies progressed, the work package splits revealed overlaps and redundancies, although some had been anticipated. The need for constant communication between Levels A and B existed, and the panels and boards set up at Level B were in response to this need. The geographic separation of the field centers also created communication problems. With resource competition among the field centers, a free flow of information would have provided Johnson a competitive advantage over other field centers.

The coordination between headquarters and program management also suffered. The associate administrator's span of authority set the stage for problems. In addition, many at the headquarters were unclear about their roles. Although NASA had begun to build the headquarters organization for the space station, by most accounts it had not been completed.

By the time NASA revisited the work package decisions in 1986, many of the field center directors had concluded that the lead center form of organization was not functioning effectively. Bill Lucas at Marshall had always believed in strong central direction from headquarters because he felt that lead center in Apollo and the application of a similar concept on a more limited scale at Marshall (prior to the shuttle) had both been unsuccessful. Based on their own experiences in the program, Andrew Stofan and even Noel Hinners, who had enthusiastically endorsed the lead center form of organization during the 1983 Langley meeting, had also come to view the concept as dysfunctional. The Challenger accident and the Rogers Commission Report on the shuttle further discredited the lead center concept.

Many viewed the lead center organization for the space station program as an experiment that would be evaluated before the development phase. As we have seen, this tentativeness regarding the program management decision had earlier dissuaded Don Hearth from accepting the lead center assignment. With the experience accumulated in the detailed definition phase, the Phillips Committee successfully persuaded the administrator to abandon the lead center concept. NASA thus affirmed the need for centralized direction from headquarters in the early phases of the program.

* * *

The management of the formative years of the space station program provided many individuals with an opportunity to learn about NASA's organizational heritage. This included management styles, organizational models, influence of external constituencies, and the delicate relationships among field centers and headquarters.

NASA had a reputation for management excellence dating back to the Apollo days. This reputation rested on the effective use of such techniques as task forces, which focused agency-wide attention on large-scale projects. As NASA became increasingly decentralized and the field centers gained increasing operational autonomy, only a few within the agency had direct experience with running agency-wide programs. Following the shuttle, NASA did not pursue another major manned program until Beggs and Mark proposed the space station. The Space Station Task Force helped to rekindle earlier memories, showing many individuals (who had not been involved in earlier task forces) how task forces operated and how they could be effectively managed. Also the way Beggs and Hodge chose to manage was very

conducive to intrapreneurship. The task force left a strong imprint on the evolution of the space station program, even as late as 1986, as the program moved into the preliminary design phase.

During this period, NASA also reevaluated organizational models that it had previously used for managing multicenter programs. Since the shuttle was considered to be the major manned project, many had accepted lead center as the natural option for program management. As we have seen, the Program Planning Working Group discussed the Apollo model of organization as well. The ensuing discussions, the lead center experiment, and its evaluation, brought into sharp focus the complexity of all management decisions. NASA learned the problems of establishing intercenter cooperation without strong central direction from headquarters.

During the Apollo era, James Webb had emphasized the importance of external constituencies. Over time, as budgets shrank and Congressional oversight intensified, dealing with external constituencies became headquarters' primary responsibility. Many within NASA came to understand that the program guidelines (e.g., building the station by the yard, or no single prime contractor) reflected the need for constituencies. Even field center personnel developed an appreciation of the power of constituencies. For example, W. Ray Hook, who first tackled the work package issue, quickly came to realize the power exerted by forces outside NASA.

Many in NASA learned, for the first time, the kinds of relationships that existed among the field centers and headquarters. Ron Browning of Goddard, for instance, came to appreciate the uniqueness of his center, especially how scientists were accustomed to working within specified boundaries, not like the interdependent situation created by the lead center experiment. The work package negotiations also created an awareness of the delicate historical relationships between Johnson and Marshall. Lewis, under a dynamic leader, renewed its mission and enhanced its credibility among the field centers and at headquarters.

Thus, in the midst of the problems, challenges, and tangible achievements of the space station program during the period from 1982 to 1986, NASA accomplished a major task. It provided a new and relatively young (by NASA standards) cadre of personnel perhaps the best means of development—on-the-job training. Many associated with the space station during this period have undoubtedly built agency-wide relationships that will serve them well. Many had the opportunity to discover how task forces could be effectively managed. They saw how circumstances outside the agency impacted all programs within the agency. And many witnessed the design and results of a grand management experiment, "keeping the dream alive" and establishing the space station program as a major program within NASA.

NOTES

Chapter 1

1. For the number (perhaps 33) see Howard McCurdy, *A History of the Space Station Task Force*, forthcoming, p. 479, footnote 5. In fictional accounts, the idea of constructing a space station existed well into the middle of the nineteenth century. See, for example, Barton C. Hacker, "The Idea of Rendezvous: From Space Stations and Orbital Operations in Space-Travel Thought, 1895-1951," *Technology and Culture* 15 (1974):373-388. The history of the space station concept and its policy history as a NASA initiative are treated by Sylvia D. Fries, "Space Station: Evolution of a Concept," NASA History Office files; W. Ray Hook, "Historical Review," *History of the ASME: Journal of Engineering for Industry* 106 (November 1984):276-286; and John Logsdon, "Space Stations: A Policy History," a manuscript prepared for the Johnson Space Center, NASA Contract NAS9-16461, undated. On the role of nontechnical factors in shaping new technology, see Sylvia D. Fries, "2001 to 1994: Political Environment and the Design of NASA's Space Station System," *Technology and Culture* 29 (1988):568-593.

2. See, for example, the summary of the early Langley studies at Langley Research Center, "A Report on the Research and Technological Problems of Manned Rotating Spacecraft," NASA Technical Note D-1504, August 1962. For Skylab's history, see W. David Compton and Charles D. Benson, *Living and Working in Space: A History of Skylab*, NASA SP-4208 (Washington, D.C.: U.S. Government Printing Office, 1983). The Apollo activities are treated in Courtney G. Brooks, James M. Grimwood, and Lloyd S. Swenson, *Chariots for Apollo: A History of Manned Lunar Spacecraft*, NASA SP-4205 (Washington, D.C.: U.S. Government Printing Office, 1979). For a general perspective on the history of NASA and its predecessor, NACA, see Frank W. Anderson, *Orders of Magnitude: A History of NACA and NASA, 1915-1980*, NASA SP-4403 (Washington, D.C.: U.S. Government Printing Office, 1981); George W. Gray, *Frontiers of Flight: The Story of NACA Research* (New York: Alfred A. Knopf, 1948); and Robert L. Rosholt, *An Administrative History of NASA, 1958-1963*, NASA SP-4101 (Washington, D.C.: U.S. Government Printing Office, 1966).

3. See, for example, W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988; John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988; Jerry Craig, interview conducted by Thomas J. Lewin, March 17, 1988; and Robert Marshall, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 21, 1988.

4. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988; McCurdy, op. cit., pp. 54-76.

5. Biographical profiles for most of the people mentioned in this book can be found in appendix C.

6. U.S. Senate Committee on Commerce, Science, and Transportation, *Nominations—NASA*, 97th Congress, 1st Session, June 17, 1981, p. 3.

7. Beggs interview, May 25, 1988.

8. Senate Committee, *Nominations*, p. 7. See also Hans Mark, *The Space Station: A Personal Journey* (Durham, N.C.: Duke University Press, 1987) pp. 10-31.

9. Beggs interview, May 25, 1988.

10. See, for example, Beggs interview, May 25, 1988.

11. Erasmus H. Kloman, *NASA: The Vision and the Reality* (Washington, D.C.: National Academy of Public Administration, 1985) pp. 12-14. See also James E. Webb, *Space Age Management: The Large Scale Approach* (New York: McGraw Hill, 1969) for Webb's views on patterns of organization and administration in the agency.

12. Senate Committee, *Nominations*, pp. 18-19.

13. Ibid., p. 19.

14. Ibid.

15. Ibid., p. 12.

16. Ibid., p. 21.

17. During his confirmation hearings, Beggs listed his priorities:
    1. The technical and management challenge of completing the shuttle flight test program and establishing a viable space transportation operational system.
    2. Developing a direction and plan which would focus the agency's activities on the next major national objectives in space.
    3. Maintaining and strengthening NASA morale and in-house capabilities in research, technology, and program management while supporting the administrations Economic Recovery Program in a responsible manner.
    4. Managing the agency's programs within the austere fiscal constraints imposed by the fiscal year 1982 budget. Senate Committee, op. cit., p. 4.

18. Ibid., p. 22.

19. Ibid., p. 19.

20. Ibid., p. 22.

21. See, for example, the article in *Science*, April 8, 1983, p. 172.

22. Kloman, *Vision and Reality*, p. 47.

23. See for example, Senate Committee, *Nominations*, pp. 4-5. Beggs interview, May 25, 1988.

24. Beggs interview, May 25, 1988.

25. Ibid.

26. Mark interview, June 20, 1988.

27. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

28. For the organization charts and a discussion, see NASA Office of Management, "The Evolution of the NASA organization," November 1983.

29. Mary D. Kerwin, interview conducted by Thomas J. Lewin, April 12, 1988.

30. Professor John Logsdon is currently pursuing the full extent of the international dimension in the space station program. This dimension is mentioned here only to point out some of the managerial efforts required.

31. Beggs interview, May 25, 1988.

32. Culbertson interview, June 8, 1988.

33. Ibid.

34. Mark interview, June 20, 1988.

35. Culbertson interview, June 8, 1988.

36. Mark interview, June 20, 1988.

37. Ibid.

38. Beggs interview, May 25, 1988.

39. Ibid.

40. Ibid.

41. Ibid.

42. In preparation for higher-level discussions, several potential international partners were approached. ESA, Japan, and Canada became the focus of later negotiations between Beggs and government officials. Based on the program chronology prepared by Adam Gruen, we could identify at least three references to such meetings before the Space Station Task Force was formed. The first was on March 19, 1982, when Ivan Bekey (Office of Space Flight) and Danny Herman (Director, Space Station Concept Development, Office of Space Science and Applications) informally met with Gottfried Greger of the Federal Republic of Germany to discuss the potential of cooperation between the U.S. and the Federal Republic of Germany with respect to the space station development. The second referred to Ivan Bekey's meeting with Jacques Collet, Head of Long Range Planning, Space Transportation Systems Office, ESA, on May 7, 1982, to prepare a draft agreement for ESA/NASA planning coordination on the space station. The third is a memo Kenneth Pederson sent to John Hodge entitled "Space Station Efforts in Japan," May 5, 1982. See Adam L. Gruen and Lorie J. Morris, *Chronology of Activities of NASA's Space Station Task Force and the U.S./International Space Station Program*, edition 1.1, March 1987 (Space Station History Project, NASA History Office, NASA, Washington, D.C.) pp. 5-32.

43. Beggs interview, May 25, 1988.

44. We should note that there was no formal title "Space Station Projects Office" in JSC at that time, since the program had not yet been approved. Yet the telephone log at JSC specifically noted a projects office with Clarke Covington as the projects officer as early as 1981. Abrahamson's visit and Kraft's creation of the office were communicated to us during our interview with Thomas Mancuso at JSC on February 25, 1988.

45. Mark interview, June 20, 1988.

46. Ibid.

47. Beggs interview, May 25, 1988.

48. Mark interview, June 20, 1988.

49. Culbertson interview, June 8, 1988.

50. Beggs interview, May 25, 1988.

51. Gerald Griffin, interview conducted by Thomas J. Lewin, March 17, 1988.

Chapter 2

1. During the Apollo period the United States was willing to invest much more money in the space program. Science and technology throughout the nation benefitted from the Apollo "umbrella." As Beggs noted, "the econometric studies we had over the years seemed to indicate that the multiplier of our expenditures on space exploration and science and technology related to space are in the order of somewhere between 5 and 8." However, in the 1980s times were different and politically NASA could not get approval for a major project unless it developed a fairly broad constituency. The space station program was no exception. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988.

2. Hodge had directed one of the space station studies run by JSC towards the conclusion of Apollo, and had helped set up the ground control systems for Mercury and Gemini. John D. Hodge, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 28, 1987.

3. Philip E. Culbertson, interview conducted by V.K. Narayanan, May 24, 1988.

4. Beggs interview, May 25, 1988.

5. Beggs interview, May 25, 1988. Hodge recalled a meeting at which Culbertson noted with approval the way he ran the task force, apparently much in line with the principles espoused in *Search of Excellence* (by Thomas J. Peters and Robert Waterman, New York: Harper & Row, 1982). According to Hodge, Phil Culbertson "had just read it, he had it with him on the plane. And he said, 'Have you seen this book?' And I said no. He said, 'These guys are as nutty as you are.' Hans Mark, and this is what he suggested, it's right down the line we had been running the task force."

6. John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988. Biographical sketches of Hodge, Finn, and Herman are found in McCurdy, op. cit., pp. 92-95, 97-99, and 100-102.

7. Hodge interview, May 24, 1988.

8. Ibid. A sketch of Freitag's biography is found in McCurdy, op. cit., pp. 102-106.

9. Ibid. See also the pamphlets prepared for NASA: Walter Froelich, "Space Station: The Next Logical Step" (Washington, D.C.: U.S. Government Printing Office, no date, approximately 1985) and James M. Beggs, "Space Station: The Next Logical Step" (Washington, D.C.: U.S. Government Printing Office, no date, approximately 1984).

10. Ibid.

11. Ibid.

12. Beggs interview, May 25, 1988.

13. Ibid.

14. See McCurdy, op. cit., p. 107, for a further discussion of the presentation.

15. See McCurdy, op. cit., p. 108. James M. Beggs, Special Announcement, Establishment of a Space Station Task Force, May 20, 1982, NASA History Office, Space Station files.

16. Hodge interview, May 24, 1988.

17. Ibid.

18. Ibid.

19. Ibid.

20. Ibid.

21. L.J. Borgoiss III and David R. Prodwin, "Strategy Implementation: Five Approaches to An Elusive Phenomenon," mimeographed paper, Stanford University, Palo Alto, Calif., May 1982. The term was first used in this paper.

22. Hodge interview, May 24, 1988.

23. Ibid.

24. Daniel H. Herman, working paper, notes taken by V.K. Narayanan, May 23, 1988; Hodge interview, May 24, 1988; Culbertson interview, May 24, 1988.

25. Herman working paper, May 23, 1988.

26. Culbertson interview, May 24, 1988.

27. Hodge interview, May 24, 1988.

28. Howard McCurdy has told the story of how the Space Station Task Force helped build the constituency for the space station program (McCurdy, op. cit.). NASA had a historical legacy of task forces and the 1980 version was a continuation of that legacy. The Space Station Task Force was patterned loosely after the Space Task Group of the 1958-62 period which had formulated the manned space program, and was also influenced by a 1970s version of the task force. (For further information, see Hodge interview, September 28, 1987, and Robert F. Freitag, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 29, 1987.)

29. Hodge interview, May 24, 1988.

30. See, for example, Erasmus H. Kloman, *Unmanned Space Project Management: Surveyor and Lunar Orbiter*, NASA SP-4901 (Washington, D.C.: U.S. Government Printing Office, 1972).

31. Freitag interview, September 29, 1987. McCurdy, op. cit., pp. 176-179.

32. Kenneth Frost, working paper, notes taken by V.K. Narayanan, April 15, 1988. Kenneth Sizemore, working paper, notes taken by Thomas J. Lewin and V.K.Narayanan, April 14, 1988.

33. McCurdy, op. cit., p. 182.

34. Brian Prichard, working paper, notes taken by Thomas J. Lewin, June 21, 1988.

35. Mark interview, June 20, 1988.

36. Freitag interview, September 29, 1987.

37. Hodge interview, May 24, 1988.

38. In 1973 Hoban had started an innovative office from scratch at NASA, the Low Cost Systems Office. In 1976 he went to General Motors as an Executive Interchange Fellow. He came back to NASA in 1977, and because of his interest in changing things, he was asked to sit on a task force to implement the Civil Service Reform Act, one of the greatest accomplishments of the Carter Administration. From there he went on the be the director of administration for the President's Commission on the accident at Three Mile Island. After finishing that, in December 1979, he was

asked to put together a commission on alcoholism. The Department of Health and Human Services had a record of poorly managed commissions, so their officials talked to Hoban who "decided, why not, one more, you know?" When he came back to the agency, he was immediately put on another task force on productivity. Frank Hoban, interview conducted by Thomas J. Lewin, April 12, 1988.

39. Hoban interview, April 12, 1988.

40. Hodge interview, May 24, 1988.

41. Philip E. Culbertson, personal communication, June 1989.

42. Freitag interview, September 29, 1987.

43. Hoban interview, April 12, 1988.

44. Hodge interview, May 24, 1988.

45. Ibid.

46. Ibid.

47. Ibid. R. Wayne Young, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17 1988. Jerry Craig, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

48. Hoban interview, April 12, 1988.

49. Freitag interview, September 29, 1987.

50. Frank S. Hoban, "The Space Station Task Force: a Study of Management Style," unpublished paper, April 12, 1988, p. 7.

51. Terence T. Finn, working paper, notes taken by V.K. Narayanan, April 14, 1988.

52. Finn, working paper, April 14, 1988. Freitag interview, September 29, 1987.

53. Hoban, op. cit., p. 6.

54. Freitag interview, September 29, 1987.

55. Ibid.

56. Hoban, op. cit., p. 12.

57. Freitag interview, September 29, 1987.

58. Ibid.

59. Hoban, op. cit., pp. 12-13. Confirmed by Hodge interview, May 24, 1988.

60. Hoban, op. cit., p. 4.

61. Hoban interview, April 12, 1988.

62. Hoban captures a sense of this: "In most cases a lively debate preceded the director's decision. If a member felt strongly pro or con, there would be ample opportunity to debate the issue openly.

It was acceptable to disagree. This was the normal decision-making mode, but the director always retained the right to limit staff participation." Hoban, "Task Force," p. 15.

63. Ibid., p. 20.

64. Ibid., p. 21. Freitag interview, September 29, 1987.

65. Hoban, op. cit., p. 21.

66. Jerry Craig, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 26, 1988.

67. Hoban, op. cit., p. 5.

68. Culbertson interview, May 24, 1988.

69. Ibid.

70. E. Lee Tilton, interview conducted by Thomas J. Lewin, December 8, 1987. McCurdy, op. cit.

71. McCurdy, op. cit., p. 201-203 discusses the role played by viewgraphs to maintain consistency.

72. Hodge interview, May 24, 1988.

73. Ibid.

74. Margaret "Peggy" Finarelli, interview conducted by Thomas J. Lewin, July 12, 1988.

75. George A. Keyworth, "Federal R&D: Not an Entitlement," *Science*, February 19, 1983.

76. Burton Edelson, working paper, notes taken by V.K. Narayanan, May 25, 1988. Mark interview, June 20, 1988.

77. Edelson, working paper, May 25, 1988.

78. Ibid. and Frost, working paper, April 15, 1988.

79. Edelson, working paper, May 25, 1988.

80. Ibid.

81. Ibid.

82. Ibid.

83. Ibid.

84. See, for example, *Science*, April 1983.

85. Edelson, working paper, May 25, 1988.

86. Culbertson interview, May 24, 1988.

87. Frost, working paper, April 15, 1988.

88. Noel Hinners, interview conducted by Thomas J. Lewin and V.K. Narayanan, December 1, 1987.

89. Edelson, working paper, May 25, 1988.

90. President Ronald Reagan, State of the Union Message, January 25, 1984.

91. Beggs interview, May 25, 1988.

92. Ibid.

93. Mark interview, June 20, 1988.

94. Edelson, working paper, May 25, 1988.

Chapter 3

1. For NACA's activities and growth, see Alex Roland, *Model Research: The National Advisory Committee for Aeronautics, 1915-1958*, NASA SP-4103 (Washington, D.C.: U.S. Government Printing Office, 1985), especially Vol. 1.

2. This is a widely held perception throughout the agency. See, for example, Clarke Covington and Robert O. Piland, "Space Operations Center: Next Goal for Manned Space Flight?" *Astronautics and Aeronautics* September 1980, pp. 30-37.

3. This perception is widespread at Goddard Center as well as headquarters. For the formative years see Alfred Rosenthal, *The Early Years: Goddard Space Flight Center* (Washington, D.C.: U.S. Government Printing Office, 1962), pp. 1-106. Also Kenneth Frost, working paper, notes taken by V.K. Narayanan, April 15, 1988; and Kenneth Sizemore, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, April 14, 1988.

4. John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988. A discussion of this organizational structure is found in Hans Mark and Arnold Levine, *The Management of Research Institutions: A Look at Government Laboratories*, NASA SP-481 (Washington, D.C.: U.S. Government Printing Office, 1984) pp. 91-235. Howard McCurdy, *A History of the Space Station Task Force*, forthcoming, treats the environmental influences on NASA's policy decisions in the early 1980s.

5. Robert F. Freitag, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 29, 1987. John D. Hodge, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 28, 1987.

6. Hans Mark, interview conducted by V.K. Narayanan, June 20, 1988. See also, Arnold S. Levine, *Managing NASA in the Apollo Era*, NASA SP-4102 (Washington, D.C.: U.S. Government Printing Office, 1982). See Apollo Program Management, U.S. House of Representatives, Subcommittee on NASA Oversight, Committee on Science and Astronautics, 91st Congress, 1st Session, 1969.

7. A good illustration of this is the space telescope and its management from the Goddard Center.

8. See, for example, William Snead, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 19, 1988, for this particular viewpoint. For confirmation see Terence T. Finn, working paper, notes taken by Thomas J. Lewin, December 7, 1987.

9. Jerry Craig, "A NASA Study of Space Station Systems Engineering and Integration," November 22, 1982, offers complete analysis of the shuttle experience. Craig's "A NASA Study of Space Station Systems Engineering and Integration," December 8, 1982, and his "Apollo/STS Systems Engineering Comparison," December 7, 1982, offers comparisons with the shuttle experience; E. Lee Tilton files.

10. Mark interview, June 20, 1988; Jerry Craig, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 26, 1988.

11. Examples of this view are found in William Lucas, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 20, 1988. Freitag interview, September 29, 1987.

12. Freitag interview, September 29, 1987. Jack C. Swearingen, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 19, 1988. Richard Peterson, working paper, notes taken by Thomas J. Lewin, June 23, 1988.

13. Jerry Craig, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 25, 1988. Allen Louviere, interview conducted by Thomas J. Lewin, February 26, 1988.

14. Lucas, working paper, January 20, 1988; Swearingen, working paper, January 19, 1988.

15. Jerry Craig, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988; Louviere, February 25, 1988; Clarke Covington, interview conducted by Thomas J. Lewin, March 16, 1988; Lucas, working paper, January 20, 1988; Swearingen, working paper, January 19, 1988.

16. W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988; Robert "Skip" Nunamaker, interview conducted by Thomas J. Lewin, June 15, 1988.

17. Hook and Nunamaker interviews, June 15, 1988.

18. Letter from Donald P. Hearth to Dr. Alan M. Lovelace, January 21, 1981. The letter encloses the NASA *Project Management Study: Final Oral Report* and includes briefing charts and notes; NASA History Office files.

19. Hook interview, June 15, 1988. See also the Hearth Committee's recommendations.

20. See McCurdy, op. cit., p. 180 for an explanation of Hodge's reasoning.

21. Mark interview, June 20, 1988.

22. Hodge interview, May 24, 1988.

23. Ibid.

24. Ibid.

25. Ibid.

26. Ibid.

27. Ibid.

28. Finn, working paper, April 14, 1988. Robert F. Freitag, interview conducted by Thomas J. Lewin, December 9, 1987.

29. Note from Terence T. Finn to John Hodge, September 8, 1982; Space Station History Project files.

30. Tilton interview, December 8, 1987.

31. "Presentation to the Space Station Program Review Committee." A similar argument is made in John D. Hodge, "Space Station Task Force Program Definition Process," January 25, 1983; E. Lee Tilton files.

32. See "Presentation to the Space Station Program Review Committee. Issues in the Development of the Definition Phase of the Program Plan." September 15, 1982. E. Lee Tilton files.

33. See "Presentation to the Space Station Program Review Committee."

34. Tilton interview, December 8, 1987.

35. "Presentation to the Space Station Program Review Committee. Appendix A: Key Program Management Decisions in Space Station Task Force: Schedule & Status Summary." March, 1983; E. Lee Tilton files.

36. "Program Planning Working Group Presented to Program Review Committee," NASA Johnson Space Center, October 14, 1982.

37. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988.

38. Beggs interview, May 25, 1988.

39. William P. Raney, interview conducted by Thomas J. Lewin and V.K. Narayanan, December 10, 1987.

40. Craig, "Systems Engineering and Integration," November 22, 1982; Craig, "Apollo/STS," December 7, 1982; E. Lee Tilton files.

41. Craig, "Apollo/STS," December 7, 1982.

42. See, for example, Hodge interview, May 24, 1988.

43. See, for example, "Pre-Phase B Space Station SE&I," January 1983, prepared by the Program Planning Working Group; E. Lee Tilton files.

44. See "Technical Evaluation Advanced Development Proposals for Space Station," February 16, 1983.

45. R. Wayne Young, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

46. Craig interview, March 17, 1988.

47. Craig, "Systems Engineering and Integration," November 22, 1982.

48. These accomplishments are elaborated upon in a series of white papers delivered by members of the PPWG at various briefings and presentations. Several of these papers are located in the NASA History Office Space Station Task Force files. The complete set is found in E. Lee Tilton files.

Chapter 4

1. See, for example, note from Terence T. Finn to John Hodge, September 8, 1982; Space Station History Project files.

2. John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988.

3. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 28, 1988.

4. Noel Hinners, interview conducted by V.K. Narayanan, June 7, 1988.

5. Hinners interview, June 7, 1988.

6. Culbertson interview, June 28, 1988.

7. Culbertson interview, June 28, 1988.

8. W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988.

9. Hook interview, June 15, 1988.

10. James R. Hawker and Richard S. Dali, "Anatomy of an Organizational Change Effort at the Lewis Research Center," National Aeronautics and Space Administration, Contract C21660-K, April 1988.

11. Andrew J. Stofan, interview conducted by Thomas J. Lewin and V.K. Narayanan, May 23, 1988.

12. Stofan interview, May 23, 1988.

13. Although Griffin had been appointed director when he was outside NASA, he was not a newcomer to NASA or to the Johnson Space Center. He had a long tenure at Johnson Space Center when Christopher Kraft was Johnson's director. Griffin had served as deputy director to Richard Smith, center director at Kennedy Space Center. Griffin also had spent time in Washington, D.C., before he left for private industry. Gerald Griffin, interview conducted by Thomas J. Lewin, March 17, 1988.

14. Jack C. Swearingen, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 19, 1988; Griffin interview, March 17, 1988. The five so-called "barons" at JSC in 1983 were: Arnold D. Aldrich, Manager, Space Shuttle Projects Office; Glenn S. Lunney, Manager, National Space Transportation Systems Program Office; C.E. Charlesworth, Director of Space Operations; Aaron Cohen, Director of Research and Engineering; and William R. Kelly, Director of Center Support.

15. Aaron Cohen, interview conducted by Thomas J. Lewin, March 17, 1988.

16. Jerry Craig, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

17. Griffin interview, March 17, 1988.

18. Brian Prichard, working paper, notes taken by Thomas J. Lewin, June 21, 1988; Mark Nolan, working paper, notes taken by Thomas J. Lewin, March 23, 1988.

19. Hodge and Beggs had projected that the space station would cost between $4 and $6 billion in its initial operational capabilities, would sustain a permanent human presence in space, and would conduct many of the missions that had been identified by the Mission Analysis Working Group. The cost was more than the $3 billion station that the Fletcher Committee had proposed and considerably more than the $1.4 billion space platform that Marshall had proposed. As Luther Powell and the Concept Development Group (CDG) looked at the issue, however, Powell came to the conclusion that the $4-6 billion figure was unrealistically low. He based this conclusion on many factors, most importantly the fact that the power requirements were more than the task force had earlier predicted. (Howard McCurdy, op. cit., delineates the discussions over the $8 billion figure and the CDG's deliberations. See pp. 307-310, 344-348, 591-594. His views were confirmed by interview with John Hodge, May 24, 1988.) He figured the cost would be somewhere between $7 billion and $12 billion, depending on the options and sophistication of the system. He suggested that NASA aim for an $8-9.5 billion station, which would give the agency considerable flexibility for growth and international participation. But Beggs had instructed Powell to look at a station within

the $7-9 billion range. With this mandate the CDG worked on the cost studies throughout the summer of 1983. After discussing the question of cost with his assistants in the administrative office, Beggs made a decision. A letter setting forth his decision was drafted and signed. In FY84 dollars, a 1991 IOC would require approximately $8 billion, with FY85 costs of approximately $225 million. Beggs thus committed NASA to design and construct a space station and make it operational for $8 billion. (McCurdy,op. cit., p. 345. This is confirmed by interviews with Hans Mark and John Hodge. Margaret Finarelli, interview conducted by Thomas J. Lewin, July 12, 1988.)

20. McCurdy, op. cit., p. 346; Hodge interview, May 24, 1988.

21. Frank Hoban, interview conducted by Thomas J. Lewin, April 12, 1988.

22. Hoban interview, April 12, 1988.

23. Hodge interview, May 24, 1988.

24. NASA, Space Station Task Force, Space Station Management Colloquium White Paper, August 1983. Materials from the Wallops colloquium are contained in Space Station Colloquia, August 29-September 1, 1983, NASA History Office Space Station Task Force Files.

25. Culbertson's remarks are reprinted in the Space Station Colloquia materials.

26. Robert F. Freitag, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 29, 1987; William Lucas, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 20, 1988; William Snead, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 20, 1988; James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988; R. Wayne Young, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988; Jerry Craig, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 26, 1988; Robert "Skip" Nunamaker, interview conducted by Thomas J. Lewin, June 14, 1988.

27. Craig, working paper, February 26, 1988.

28. Nunamaker interview, June 14, 1988; Stofan interview, May 23, 1988; Griffin interview, March 17, 1988.

29. Richard Peterson, the Director of Langley Research Center in June 1988, did not remember making this statement. Hoban, however, thought he did. Richard Peterson, working paper, notes taken by Thomas J. Lewin, June 23, 1988.

30. Hoban interview, April 12, 1988.

31. Hodge interview, May 24, 1988. This view was undoubtedly largely based on the historical experiences of the space telescope.

32. Stofan interview, May 23, 1988. See chapter 1 for these appointments.

33. Stofan interview, May 23, 1988; Griffin interview, March 17, 1988.

34. Griffin interview, March 17, 1988.

35. Stofan interview, May 23, 1988.

36. Ibid.

37. Ibid.

38. McCurdy, op. cit., p. 392.

39. Paul F. Holloway, interview conducted by Thomas J. Lewin, June 14, 1988.

40. Hodge interview, May 24, 1988.

41. Hoban interview, April 12, 1988.

42. Hodge interview, May 24, 1988.

43. Hoban interview, April 12, 1988.

44. Stofan interview, May 23, 1988.

45. Lucas, working paper, January 20, 1988.

46. Stofan interview, May 23, 1988.

47. Noel Hinners, interview conducted by V.K. Narayanan, June 7, 1988.

48. Griffin interview, March 17, 1988.

49. McCurdy, op. cit., p. 399.

50. Hoban interview, April 12, 1988.

51. Space Station Colloquia files.

52. Burton Edelson, working paper, notes taken by V.K. Narayanan, May 25, 1988.

53. Space Station Management Colloquium White Paper, August 1983, pp. 17-19.

54. McCurdy, op. cit., p. 402.

55. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988; McCurdy, op. cit., p. 402.

56. Hodge interview, May 24, 1988; Hoban interview, April 12, 1988.

57. Griffin interview, March 17, 1988; Craig interview, March 17, 1988; Cohen interview, March 17, 1988.

Chapter 5

1. Gerald Griffin, interview conducted by Thomas J. Lewin, March 17, 1988.

2. Griffin interview, March 17, 1988.

3. Griffin interview, March 17, 1988.

4. Jerry Craig, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

5. Robert F. Freitag, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 29, 1987.

6. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

7. Hans Mark, interview conducted by V.K. Narayanan, June 20, 1988.

8. Culbertson interview, June 8, 1988.

9. Hodge interview, May 24, 1988.

10. See, for example, Freitag interview, September 29, 1987.

11. Craig interview March 17, 1988.

12. Craig interview, May 24, 1988.

13. Hodge interview, May 24, 1988.

14. Hodge interview, May 24, 1988. See also NASA, Space Station Task Force, Space Station Management Colloquium White Paper, August 1983.

15. Hodge interview, May 24, 1988. See also NASA, Center Directors' Meeting, Space Station Discussion, Goddard Space Flight Center, December 12, 1983.

16. Hodge interview, May 24, 1988; Griffin interview, March 17, 1988.

17. William Lucas, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 20, 1988; Griffin interview, March 17, 1988.

18. Culbertson interview, June 8, 1988.

19. Hodge interview, May 24, 1988.

20. Hodge interview, May 24, 1988.

21. Hans Mark, interview conducted by V.K. Narayanan, June 20, 1988.

22. Mark interview, June 20, 1988.

23. Dr. Mark's reasons were seen differently by other NASA personnel at headquarters and the centers.

24. Griffin interview, March 17, 1988.

25. Hodge interview, May 24, 1988.

26. Aaron Cohen, interview conducted by Thomas J. Lewin, March 17, 1988.

27. Ibid.

28. Hodge interview, May 24, 1988.

29. Ibid.

30. See, for example, Thomas Mancuso, interview conducted by Thomas J. Lewin and V.K. Narayanan, February 25, 1988.

31. Griffin interview, March 17, 1988; John Aaron, interview conducted by Thomas J. Lewin, April 12, 1988.

Chapter 6

1. Ron Thomas, "Some Thoughts on Space Station Advanced Development Program Developed for the Space Station Task Force Program Planning Working Group," January 13, 1983. E. Lee Tilton files.

2. Ibid.

3. Ibid.

4. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

5. Ibid.

6. McCurdy, op. cit., pp. 404-405.

7. Culbertson interview, June 8, 1988.

8. McCurdy, op. cit., p. 407.

9. Aaron Cohen, interview conducted by Thomas J. Lewin, March 17, 1988.

10. Culbertson interview, June 8, 1988.

11. Andrew J. Stofan, interview conducted by Thomas J. Lewin and V.K. Narayanan, May 23, 1988.

12. Culbertson interview, June 8, 1988.

13. Hans Mark, interview conducted by V.K. Narayanan, June 20, 1988.

14. Culbertson interview, June 8, 1988.

15. Ibid.

16. John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988.

17. Culbertson interview, June 8, 1988.

18. Noel Hinners, interview conducted by V.K. Narayanan, June 7, 1988.

19. Richard Peterson, working paper, notes taken by Thomas J. Lewin, June 23, 1988; Robert "Skip" Nunamaker, interview conducted by Thomas J. Lewin, June 15, 1988; Paul F. Holloway, interview conducted by Thomas J. Lewin, June 14, 1988; Roger Breckenridge, interview conducted by Thomas J. Lewin, June 14, 1988.

20. See Hans Mark and Arnold Levine, *The Management of Research Institutions: A Look at Government Laboratories*, NASA SP-481 (Washington, D.C.: U.S. Government Printing Office, 1984), p. 289.

21. Adam L. Gruen and Lorie J. Morris, *Chronology of Activities of NASA's Space Station Task Force and the U.S./International Space Station Program*, edition 1.1, (Washington, D.C.: U.S. Government Printing Office, March 1987), p. 56.

22. Gruen and Morris, op. cit., p. 57.

23. Hook, a detailee from Langley who had been recruited by Luther Powell, had joined the Concept Development Group at the beginning of May 1983, and worked with it until January 1984, following President Reagan's State of the Union Message. W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988.

24. Hook interview, June 15, 1988.

25. Ibid.

26. Some of the capabilities that were to be included were 1) a laboratory for provisional research development and demonstration in a pressurized environment. It continued manned interaction and external attachments to which unpressurized experiments and payloads might be connected; 2) private crew quarters, a ward room, and a galley to provide essential health and recreational needs; 3) electrical power, thermal control, data processing, communications, attitude control, and orbit maintenance; 4) multiple berthing, the coupling unit to which the space station modules would be connected and within which space suits would be stored and serviced; and 5) required consumable items. It would also contain facilities for crew hygiene and material to be returned to the ground; 6) attachment facilities and hangars for servicing, and where satellites and the orbital maneuvering vehicle would be serviced, refueled, and stored; 7) unmanned spacecraft, called platforms, operated or serviced from the space shuttle or space station, that would provide power, thermal control, data transmission, attitude control, and orbit maintenance for a complement of payloads; and 8) support services, including equipment required to process and launch space station elements, control of the space station and platforms and consumer data interface and crew training. "Space Station $8.0 Billion Program Content," Enclosure. Space Station Task Force files.

27. Culbertson interview, June 8, 1988.

28. Ibid.

29. Ibid.

30. Ibid.

31. Ibid.

32. Ibid.

33. Ibid.

34. See, for example, Thomas Mancuso, interview conducted by Thomas J. Lewin and V.K. Narayanan, February 25, 1988; Tony Redding, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 25, 1988.

35. James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988.

36. Kingsbury interview, January 21, 1988.

37. Culbertson interview, June 8, 1988.

38. Culbertson interview, June 8, 1988; this was confirmed by John Hodge. See Hodge interview, May 24, 1988.

39. Culbertson interview, June 8, 1988.

40. Gerry Griffin, interview conducted by Thomas J. Lewin, March 17, 1988.

41. Roger E. Bilstein, *Space Station Configurations and Phase B Studies at the Johnson Space Center (1984-1986): Narrative and Chronology*, prepared under JSC Contract NAS9-17369. Skunk works is a concept that originated in the work of Clarence Kelly Johnson, an aircraft designer at Lockheed. See Chapter 7, Footnote 13, for Bob Dotts' explanation of skunk works.

42. Griffin interview, March 17, 1988.

43. Ibid.

44. Ibid.

45. Ibid.

46. Jack Lee, working paper, notes taken by V.K. Narayanan, January 21, 1988.

47. Lee, working paper, January 21, 1988; Robert Marshall, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 21, 1988.

48. Cohen interview, March 17, 1988.

49. Lee, working paper, January 21, 1988.

50. Ibid.

51. Culbertson interview, June 8, 1988; Marshall, working paper, January 21, 1988.

52. Culbertson interview, June 8, 1988.

53. Hinners interview, June 7, 1988.

54. Marshall, working paper, January 21, 1988.

55. Griffin interview, March 17, 1988.

56. Letter from Gerald D. Griffin to Philip E. Culbertson, June 5, 1984, Space Station History Project files.

57. Letter from Griffin to Culbertson.

58. Culbertson interview, June 8, 1988.

59. Ibid.

60. Ibid.

61. Ibid.

62. Hodge interview, May 24, 1988.

63. Culbertson interview, June 8, 1988.

64. Noel Hinners, interview conducted by Thomas J. Lewin and V.K. Narayanan, December 11, 1987 and interview conducted by V.K. Narayanan, June 7, 1988.

Chapter 7

1. Robert C. Goetz, "Space Station 'Level B' Functional Plan Summary," no date, pp. 2-3. Johnson Space Center History Office files.

2. Goetz, op. cit., p. 30.

3. Robert L. Dotts, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

4. James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988.

5. Goetz, op. cit.

6. For a full discussion, see John M. Logsdon, "Together in Orbit: The Origins of International Participation in the Space Station Freedom Program" (NASA History Division).

7. Dotts interview, March 18, 1988.

8. Ibid.

9. John Aaron, interview conducted by Thomas J. Lewin, April 12, 1988.

10. Ibid.

11. Goetz, op. cit.

12. Ibid.

13. Goetz, op. cit. For confirmation see W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988; Dotts interview, March 18, 1988; Jerry Craig, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988; Thomas Cochrane, interview conducted by Thomas J. Lewin, July 25, 1988; Robert Easter, interview conducted by Thomas J. Lewin, July 18, 1988.

14. NASA had previously employed skunk works. Bob Dotts, one of the workshop participants, explained skunk works: "Skunk works, in our terminology, is a way to pull together all of the right technical smarts and put them off somewhere. If you really want to get up the curve fast in terms of accomplishing something, the easiest way, and industry does the same thing, you take your best talent, you go off and lock them up so nobody else has access to them, and you focus them on this one set of tasks." Dotts interview, March 18, 1988.

15. "Concerns from Space Station Management Workshop," no date. Johnson Space Center History Office files.

16. Ibid.

17. Ibid.

18. Hook interview, June 15, 1988; Craig interview, March 17, 1988; Thomas Mancuso, interview conducted by Thomas J. Lewin and V.K. Narayanan, February 25, 1988; Cochrane interview, July 25, 1988; Easter interview, July 18, 1988; Dotts interview, March 18, 1988.

19. This was a big surprise to many, because it had been rumored that the program manager would be someone other than Hutchinson. As Hutchinson took command of the skunk works, he benefited from the work that had been done prior to the skunk works. A set of ideas that working groups had assembled to assist the functions that needed to be performed had been prepared. Langley had already built up a mission requirements data base. The PPWG had produced a strawman RFP, and

had also brought out program plans, schedules, budget data, and a plan for SE&I. The operations working group had put together the operations requirements, guidelines, concepts, approaches, and a database. Finally, the Concept Development Group and the Systems Definition Working Group had pulled together government and industry studies on the systems concepts and architecture, which would be useful for the skunk works activity. Simultaneously, the Space Station Task Force worked out the Level A requirements at headquarters. Tony Redding, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 25, 1988. Craig interview, March 17, 1988. John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988.

20. Allen J. Louviere, interview conducted by Thomas J. Lewin, February 25, 1988.

21. Craig interview, March 17, 1988.

22. Ibid.

23. Ibid.

24. Aaron interview, April 12, 1988.

25. Craig interview, March 17, 1988.

26. Aaron interview, April 12, 1988.

27. Charles Darwin, interview conducted by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

28. See, for example, Craig interview, March 17, 1988; and Neil B. Hutchinson, interview conducted by Thomas J. Lewin,July 28, 1988.

29. Aaron interview, April 12, 1988.

30. Ibid.

31. Ibid.

32. Craig interview, March 17, 1988.

33. Ibid.

34. Kingsbury interview, January 21, 1988.

35. Ibid.

36. Ibid.

37. For a full discussion of nontechnical considerations, see Sylvia Fries "2001 to 1994: Political Environment and the Design of NASA's Space Station System," *Technology and Culture* 29, July 1988, pp. 568-593.

38. Darwin interview, January 20, 1988.

39. Ibid.

40. McCurdy, op. cit., pp. 302-304, 344-346.

41. Aaron interview, April 12, 1988.

42. Ronald Browning, interview conducted by Thomas J. Lewin and V.K. Narayanan, April 14, 1988; Goetz, op. cit.

43. Craig interview, March 17, 1988.

44. Ibid.

45. Ibid.

Chapter 8

1. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

2. Before Beggs took over, Culbertson had been a deputy associate administrator, which was technically within the Office of Space Transportation Systems. The shuttle had been delayed, causing great concern in the Carter Administration. The White House had asked the administrator's office to become more involved in the program; for instance, monthly reports were required from the administrator on the state of the shuttle. Allen Lovelace, the deputy administrator, was asked by Administrator Robert Frosh to become more involved in the shuttle's activities. Lovelace, unfamiliar with the workings of the space shuttle, asked Culbertson to be his special assistant for space transportation systems, strictly a staff job. Culbertson served in that capacity for the first two or three launches. As long as Lovelace remained, Culbertson continued in that capacity. Culbertson interview, June 8, 1988.

3. Culbertson interview, June 8, 1988.

4. Ibid.

5. William P. Raney, interview conducted by Thomas J. Lewis and V.K. Narayanan, December 10, 1987.

6. Culbertson interview, June 8, 1988.

7. Ibid. and John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988.

8. James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988; Thomas G. Mancuso, interview conducted by Thomas J. Lewin and V.K. Narayanan, February 25, 1988.

9. Mancuso interview, February 25, 1988.

10. Culbertson interview, June 8, 1988.

11. See, for example, Terence T. Finn, working paper, notes taken by V.K. Narayanan, April 14, 1988.

12. Hodge interview, May 24, 1988.

13. Philip E. Culbertson, personal communication, July 1989.

14. Hodge interview, May 24, 1988.

15. See, for example, Hans Mark and Arnold Levine, *The Management of Research Institutions: A Look at Government Laboratories*, NASA SP-481 (Washington, D.C.: U.S. Government Printing Office, 1984), pp. 44-155.

16. Robert F. Freitag, interview conducted by Thomas J. Lewin, December 9, 1987.

17. In cases like this NASA typically forms an interim program office which then becomes the permanent office when the budget is finalized. In the case of the space station, there was another reason why the agency moved carefully in setting up its permanent office. Beggs, a strong Republican, was sensitive to the views of the Democratic Congress. As long as budgetary approvals had not come through, the creation of the permanent office had to wait. This way Begg's partisanship would not be perceived as influencing the agency's direction, at least as far as Congress was concerned. Culbertson interview, June 8, 1988.

18. Hodge interview, May 24, 1988.

19. For the day-to-day events at headquarters, see Gruen and Morris, op. cit., pp. 3-123.

20. Burton Edelson, working paper, notes taken by V.K. Narayanan, May 25, 1988.

21. Memo from Burton I. Edelson to Administrator, June 19, 1984. This memo deals with his views on the entire space station organization. See also Edelson, working paper, May 25, 1988, for confirmation.

22. Culbertson interview, June 8, 1988.

23. Marc Bensimon, interview conducted by Thomas J. Lewin, July 11, 1988; Louis DeAngelis, interview conducted by Thomas J. Lewin, July 12, 1988.

24. Hodge interview, May 24, 1988.

25. Ibid.

26. Ibid.

27. Ibid.

28. Ibid.

29. Culbertson interview, June 8, 1988.

30. Ibid.

31. Hodge interview, May 24, 1988.

32. Ibid.

33. Ibid.

34. Finn, working paper, April 14, 1988.

35. Griffin agreement with Culbertson.

36. William P. Raney, interview conducted by Thomas J. Lewin, May 23, 1988.

37. Raney interview, May 23, 1988.

38. Culbertson interview, June 8, 1988.

39. The activities of this committee are found in Gruen and Morris, op. cit.

40. Raney interview, May 23, 1988.

41. See Gruen and Morris, op. cit., especially pp. 98-99 and also pp. 104, 106, 109, 111, 115, 116-117 for further talks.

42. Margaret Finarelli, interview conducted by Thomas J. Lewin, July 12, 1988.

43. Culbertson interview, June 8, 1988.

44. Ibid.

45. Brian Prichard, working paper, notes taken by Thomas J. Lewin, June 21, 1988.

46. Raney interview, May 23, 1988.

47. Ibid.

48. Ibid.

49. Gruen and Morris, op. cit., p. 163.

50. Edelson, working paper, May 25, 1988. Letter from Peter M. Banks to Philip E. Culbertson, June 27, 1984. Space Station Task Force files.

51. Gruen and Morris, op. cit., p. 110; Prichard, working paper, June 21, 1988.

52. Raney interview, May 23, 1988.

53. Ibid.

54. Ibid.

55. McCurdy, op. cit., pp. 367-369, 423-425.

56. McCurdy, op. cit., p. 427.

57. Gruen and Morris, op. cit., p. 135.

58. Culbertson interview, June 8, 1988.

59. Ibid.

60. Finn, working paper, April 14, 1988.

61. Ibid.

62. John Hodge and Neil Hutchinson have differing perceptions on this issue. See Hodge interview, May 24, 1988, and Neil B. Hutchinson, interview conducted by Thomas J. Lewin, July 28, 1988.

63. Beyond these accomplishments the program office at headquarters initiated a number of moves anticipating the time when the space station would operate. For example, during this period, TMIS and the approaches to evolution and operation also received headquarters attention.

Chapter 9

1. Hodge assumed that headquarters would maintain control of program definition. Based on this assumption he also identified many of the tasks to be performed at various levels of the organization. Although the tasks associated with Level A were delineated in some detail, Hodge did not attempt to clearly distinguish among Levels B, C, and D in terms of the station's definition tasks. Some assumptions, however, were the basis of his organizational approach toward Levels A, B, and C. He assumed NASA would establish organizational limits with a clear-cut charter that was isolated from political interference, that the program would enjoy institutional support when it was needed and would establish excellent communications between headquarters and the centers. John D. Hodge, "Space Station Task Force Program Definition Process," January 25, 1983, pp. 3-8.

2. Hodge, op. cit., pp. 12-13.

3. Hodge, op. cit., pp. 6-10.

4. See JSC phone book for the year 1982; and John D. Hodge, "Presentation on Space Station Planning to the NASA Center Directors," September 22, 1982.

5. Aaron explained about the division of duties between himself and Hutchinson: "What happened there was that Level B took a split. Neil Hutchinson took the job of learning the Source Evaluation Board and bringing the RFP to the contractors. I took the job of organizing Level B and making an organization out of it, hopefully getting it tuned up and running such that when they selected contractors, we were ready to run and we had a process and organization in place." Aaron interview, April 12, 1988.

6. John Aaron, interview conducted by Thomas J. Lewin, April 12, 1988.

7. William Snead, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 19, 1988.

8. Margaret Finarelli, interview conducted by Thomas J. Lewin, July 12, 1988. Midway through the skunk works, however, as the international dimension began to assume specificity, Eugene Rice at Johnson headed an international office at Level B to integrate the internationals. The internationals worked pretty much like a project office and their studies were to be integrated much like the other work packages into the overall configuration. Rice's international office at Johnson acted as the clearinghouse for technology transfer concerns and performed all the administrative functions that Level A required. However, during the real trade studies, the focus of the definition stage, when interfaces were discussed, the international partners were treated exactly like the work package centers (Marshall, Johnson, Goddard, and Lewis). Carl B. Shelley, working paper, notes taken by V.K. Narayanan, February 26, 1988; Neil B. Hutchinson, interview conducted by Thomas J. Lewin, July 28, 1988.

9. John E. Cools, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

10. Cools interview, March 17, 1988.

11. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

12. Hutchinson interview, July 28,1988.

13. Robert L. Dotts, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

14. Dotts interview, March 18, 1988; Tony Redding, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, February 25,1988.

15. Redding, working paper, February 25, 1988. Also see the JSC phone book for the year 1982 which lists the various divisions and offices.

16. Carl B. Shelley, "Level B. Space Station Customer Integration Office," May 21, 1985, pp. 2-12.

17. Shelley, op. cit., pp. 3-8; and Aaron interview, April 12, 1988.

18. Aaron interview, April 12, 1988.

19. Ibid.

20. Neil B. Hutchinson, interview conducted by Thomas J. Lewin, August 1, 1988.

21. Hutchinson interview, July 28, 1988; Gerald Griffin, interview conducted by Thomas J. Lewin, March 17, 1988; Shelley, working paper, February 26, 1988; Richard A. Thorson, working paper, notes taken by V.K. Narayanan, February 26, 1988; Cools interview, March 18, 1988.

22. Craig interview, March 17, 1988; Hutchinson interview, July 28, 1988.

23. James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988.

24. Kingsbury interview, January 21, 1988; John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988; W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988.

25. Hodge interview, May 24, 1988; Craig interview, March 17, 1988.

26. Shelley, working paper, February 26, 1988. SSCB members were Neil Hutchinson, chair, K. Garriott, W.E. Rice, A.J. Louviere, R.A. Thorson, C.B. Shelley, T.R. Kloves, A. Cohen, C.E. Charlesworth, M.L. Raines, R.H. Kohrs, C. Covington, L.E. Powell from Marshall, R.K. Browning from GSFC, R.L. Thomas from Lewis Research Center, C.M. Giesler from KSC, W.R. Hook from Langley Research Center, R.W. Easter from JPL, and J.C. Sharp from Ames Research Center. The day-to-day workings of the SSCB are found in its minutes and directives housed in the rich and extremely well organized history office at the Johnson Space Center.

27. Dotts interview, March 18, 1988.

28. Dotts interview, March 18, 1988; Craig interview, March 17, 1988.

29. Kingsbury interview, January 21, 1988; William Snead, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 19, 1988.

30. Hutchinson interview, August 1, 1988; Craig interview, March 17, 1988.

31. Aaron interview, April 12, 1988; Hutchinson interview, August 1, 1988.

32. Kingsbury interview, January 21, 1988.

33. Memorandum for the Record, Philip E. Culbertson, January 22, 1985; Johnson Space Center History Office files. Philip E. Culbertson, interview conducted by Thomas J. Lewin and V.K. Narayanan, December 9, 1987.

34. Clarke Covington, interview conducted by Thomas J. Lewin, March 16, 1988; Snead, working paper, January 19, 1988; William Lucas, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

35. Ronald Browning, interview conducted by Thomas J. Lewin and V.K. Narayanan, April 14, 1988; Noel Hinners, interview conducted by Thomas J. Lewin and V.K. Narayanan, December 11, 1987.

36. Thomas Cochrane, interview conducted by Thomas J. Lewin, July 25, 1988; Ronald Thomas, interview conducted by Thomas J. Lewin, July 18, 1988.

37. Hook interview, June 15, 1988; Paul J. Holloway, interview conducted by Thomas J. Lewin, June 14, 1988; Robert "Skip" Nunamaker, interview conducted by Thomas J. Lewin, June 15, 1988.

38. Aaron interview, April 12, 1988.

39. For an elaboration of the details of this process, see Hans Mark and Arnold Levine, *The Management of Research Institutions: A Look at Government Laboratories* (Washington, D.C.: U.S. Government Printing Office, 1984), especially p. 120.

40. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

41. Max Egert, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

42. Egert interview, March 17, 1988.

43. Max Egert, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

44. Culbertson interview, June 8, 1988.

45. Part One: The Schedule: Section B: Significant Features of the phase B RFP. Robert L. Dotts files.

46. Dotts interview, March 18, 1988. Ron Browning also noted the RFP's newness. Browning interview, April 14, 1988.

47. Memo from Neil B. Hutchinson to DA/Senior Staff, June 28, 1984. Johnson Space Center History Office files.

48. Burton Edelson, working paper, notes taken by V.K. Narayanan, May 25, 1988.

49. Roger E. Bilstein, "Space Station Configurations and Phase B Studies at the Johnson Space Center (1984-1986): Narrative and Chronology," prepared under JSC Contract NAS9-17369, p. 23.

50. Significant Features of the RFP.

51. Henry W. Flagg, Working paper, notes taken by Thomas J. Lewin, March 24, 1988.

52. Dotts interview, March 18, 1988; Charles Darwin, interview conducted by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

53. Bilstein, op. cit.

54. Bilstein, op. cit., p. 24.

55. Bilstein, op. cit., p. 24.

56. Dotts interview, March 18, 1988.

Chapter 10

1. For details see Hans Mark, *The Space Station: A Personal Journey* (Durham: Duke University Press, 1987), pp. 215-217.

2. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988.

3. William P. Raney, interview conducted by Thomas J. Lewin and V.K. Narayanan, May 23, 1988.

4. Neil B. Hutchinson, interview conducted by Thomas J. Lewin, August 1, 1988.

5. Ibid.

6. See, for example, Robert F. Freitag, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 29, 1987, and Raney interview, May 23, 1988.

7. Hutchinson interview, August 1, 1988.

8. Jerry Craig, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

9. See, for example, Robert L. Dotts, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

10. Allen J. Louviere, interview conducted by Thomas J. Lewin, February 28, 1988.

11. John E. Cools, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

12. Hutchinson interview, August 1, 1988.

13. Louviere interview, February 25, 1988.

14. Hutchinson interview, August 1, 1988.

15. Clarke Covington, interview conducted by Thomas J. Lewin, March 16, 1988.

16. Hutchinson interview, August 1, 1988.

17. Ibid.

18. Ibid.

19. Louviere interview, February 25, 1988.

20. Margaret Finarelli, interview conducted by Thomas J. Lewin, July 12, 1988; William P. Raney, interview conducted by Thomas J. Lewin, December 10, 1987; Carl B. Shelley, working paper, notes taken by V.K. Narayanan, February 26, 1988.

21. Hutchinson interview, August 1, 1988.

22. Raney interview, May 23, 1988.

23. Covington interview, March 16, 1988.

24. Dotts interview, March 18, 1988.

25. James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988.

26. Kingsbury interview, January 21, 1988.

27. Ibid.

28. Memo from Luther E. Powell to Neil Hutchinson, March 22, 1985. Johnson Space Center History Office files.

29. Kingsbury interview, January 21, 1988.

30. Ibid.

31. Ronald Browning, interview conducted by Thomas J. Lewin and V.K. Narayanan, April 14, 1988.

32. Ibid.

33. Ibid.

34. Ibid. and Noel Hinners, interview conducted by V.K. Narayanan, June 7, 1988.

35. Browning interview, April 14, 1988.

36. Ibid.

37. Ibid.

38. Mark Nolan, working paper, notes taken by Thomas J. Lewin, March 23, 1988.

39. W. Ray Hook, interview conducted by Thomas J. Lewin, June 15, 1988.

40. Ibid.

41. Neil B. Hutchinson, interview conducted by Thomas J. Lewin, July 28, 1988.

Chapter 11

1. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988.

2. Ibid.

3. Philip E. Culbertson, interview conducted by V.K. Narayanan, June 8, 1988.

4. Ibid.

5. Ibid.

6. Philip E. Culbertson, personal communication, June 8, 1989.

7. Culbertson interview, June 8, 1988.

8. Ibid.

9. See, for example, Joseph J. Trento, *Prescription for Disaster* (New York: Crown Publishers, 1987) and Malcolm McConnell, *Challenger: A Major Malfunction* (New York: Doubleday, 1987).

10. Freitag explained: "The change of thinking has taken place now, that is, going away from the lead center concept and going back to the central management. I think it would have happened anyhow. I would say it was stimulated more by Challenger, not by the changeover of Beggs. You never can tell what would have happened, but with Challenger being, as it were, then Johnson's so busy recovering from Challenger that they wouldn't have had time to do the total job, they wouldn't have the manpower and time and resources. But we were already, before Beggs had actually quit, we were already going down the road of reversing that [the lead center decision]." Robert F. Freitag, interview conducted by Thomas J. Lewin and V.K. Narayanan, September 29, 1987.

11. Culbertson interview, June 8, 1988.

12. Ibid.

13. Ibid.

14. John D. Hodge, interview conducted by Thomas J. Lewin, May 24, 1988.

15. John Aaron, interview conducted by Thomas J. Lewin, April 12, 1988.

16. Ron Thomas, interview conducted by Thomas J. Lewin, July 18, 1988.

17. Hodge interview, May 24, 1988.

18. Ibid.

19. Ibid.

20. Culbertson interview, June 8, 1988; Hodge interview, May 24, 1988; Aaron interview, April 12, 1988; Neil B. Hutchinson, interview conducted by Thomas J. Lewin, July 28, 1988.

21. For example, redundancies appeared in the common module. This was because there had been no definition of what was common to the modules and what would be unique. Culbertson remarked, "Two things were necessary before that real decision was possible to make. Two things that did not happen before Phase B had to happen in Phase B. One was the continued definition of what a lab and a habitation module would really be. Second was a consideration of how the build-up the actual manufacturing and assembly of modules would take place. Culbertson interview, June 8, 1988.

22. Culbertson interview, June 8, 1988.

23. Hodge interview, May 24, 1988; Robert F. Freitag, interview conducted by Thomas J. Lewin, December 9, 1987; Aaron interview, April 12, 1988; Thomas interview, July 18, 1988; Ronald Browning, interview conducted by Thomas J. Lewin and V.K. Narayanan, April 14, 1988.

24. Bensimon had joined the space station program in late 1984, following Culbertson's initial work package decision. He had participated in the organizational meetings where NASA personnel had worked on the interface between Levels A, B, and C, and reported to Danny Herman who was in charge of engineering at headquarters. Marc Bensimon, interview conducted by Thomas J. Lewin, July 11, 1988.

25. Bensimon interview, July 11, 1988.

26. Ibid.

27. Ibid.

28. Marc Bensimon, "Results of the March 5/6 Work Package Analysis Team Meetings." March 12, 1986. Space Station Task Force History files.

29. Bensimon, op. cit.

30. Bensimon interview, July 11, 1988.

31. Hodge interview, May 24, 1988.

32. Ibid. and Thomas interview, July 18, 1988.

33. Thomas interview, July 18, 1988.

34. Ibid.

35. Bensimon interview, July 11, 1988; and

36. Thomas interview, July 18, 1988.

37. Bensimon interview, July 11, 1988.

38. John D. Hodge, "Space Station Work Package Recommendation," April 8, 1986. Space Station Task Force History files.

39. Hodge interview, May 24, 1988.

40. See, for example, Tony Redding, "Engineering and Manpower Projection," May 9, 1986. Johnson Space Center History Office files.

41. Hodge, op. cit.

42. Hodge interview, May 24, 1988.

43. Ibid. Phil Culbertson confirmed this view.

44. Hodge interview, May 24, 1988.

45. Ibid.

46. Ibid.

47. Freitag interview, September 29, 1987.

48. James Kingsbury, interview conducted by Thomas J. Lewin, January 21, 1988.

49. "Space Station Management: An Analysis of Work Package Options," October 3, 1986, p. 3. Submitted to the Committee on Science and Technology, U.S. House of Representatives.

50. Op. cit., pp. 10-12.

51. Unpublished paper, Space Station Task Force, March 13, 1986.

52. Hodge interview, May 24, 1988.

53. S.C. Phillips, Presentation to the Administrator, National Aeronautics and Space Administration: Report of the NASA Management Study Group, December 16, 1986, and Recommendations to the

Administrator: National Aeronautics and Space Administration, December 30, 1986. Space Station Task Force History files.

54. Hodge interview, May 24, 1988.

55. Andrew J. Stofan, interview conducted by Thomas J. Lewin and V.K. Narayanan, May 23, 1988.

56. Ibid.

57. Ibid.

Chapter 12

1. "Space Station Management: An Analysis of Work Package Options," October 3, 1986, p. 4.

2. Op. cit., p. 4.

3. John D. Hodge, interview by Thomas J. Lewin, May 24, 1988.

4. Andrew J. Stofan, interview conducted by Thomas J. Lewin and V.K. Narayanan, May 23, 1988.

5. Ibid.

6. Hodge interview, May 24, 1988; William P. Raney, interview conducted by Thomas J. Lewin and V.K. Narayanan, December 10, 1987.

7. Thomas Mancuso, interview conducted by Thomas J. Lewin and V.K. Narayanan, February 25, 1988; James McMillon, interview conducted by Thomas J. Lewin and V.K. Narayanan, January 21, 1988; Carl B. Shelley, working paper, notes taken by V.K. Narayanan, February 26, 1988.

8. Shelley, working paper, February 26, 1988.

9. Robert Dotts, interview conducted by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

10. See, for example, Mancuso interview, February 25, 1988.

11. Stofan interview, May 23, 1988; Noel Hinners, interview conducted by V.K. Narayanan, June 7, 1988.

12. Neil B. Hutchinson, interview conducted by Thomas J. Lewin, July 28, 1988.

13. Thomas L. Moser, interview conducted by Thomas J. Lewin, April 13, 1988.

14. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988.

15. Ibid.

16. William P. Raney, interviews conducted by Thomas J. Lewin and V.K. Narayanan, December 10, 1987 and May 23, 1988; Terence T. Finn, working paper, notes taken by V.K. Narayanan, April 14, 1988.

17. Hodge interview, May 24, 1988.

18. John Aaron, interview conducted by Thomas J. Lewin, April 12, 1988.

19. Ronald Browning, interview conducted by Thomas J. Lewin and V.K. Narayanan, April 14, 1988.

20. Beggs interview, May 25, 1988.

In Summation

1. James M. Beggs, interview conducted by Thomas J. Lewin, May 25, 1988.

2. Hans Mark, interview conducted by V.K. Narayanan, June 20, 1988.

3. For the conceptual development of the notion of the levels, see Talcott Parsons, "A Sociological Approach to the Theory of Organizations," in *Structure and Process in Modern Societies* (New York: Free Press, 1964). For a study of conglomerate organizations and description of the empirical reality of the functions of the levels, see J. C. Bower, *Managing the Resource Allocation Process* (New York: Irwin, 1972). For NASA's space station, see unpublished Space Station Task Force manuscript, 1985, which delineates this process in the organization.

4. The need to prepare individuals for the management task was underscored by Culbertson himself: "To treat consideration of management and how that will affect the well-being of the program is every bit as important as how one treats any kind of technical considerations. NASA brings people up, promotes them within the technical disciplines, and finally makes managers out of those that seem to do well technically. So the person who has to make decisions 30 years from now, I hope, has in 22 years from now an opportunity to be trained as a very good manager and to take management every bit as seriously as we do any kind of technical considerations." Philip E. Culbertson, interviewed by V.K. Narayanan, June 8, 1988.

5. See, for example, R. Wayne Young, interviewed by Thomas J. Lewin and V.K. Narayanan, March 17, 1988, and Jack Swearingen, interviewed by Thomas J. Lewin and V.K. Narayanan, January 19, 1988.

6. See, for example, Hans Mark, interview conducted by V.K. Narayanan, June 20, 1988, and Louis DeAngelis, interviewed by Thomas J. Lewin, July 12, 1988.

7. Andrew Stofan, interviewed by Thomas J.Lewin and V.K. Narayanan, May 23, 1988; William Lucas, working paper, notes taken by Thomas J. Lewin and V.K. Narayanan, January 20, 1988; Frank Hoban, interviewed by Thomas J. Lewin, April 12, 1988; and William Raney, interviewed by Thomas J. Lewin, May 23, 1988.

8. See, for example, Michael Tushman and W.L. Moore, eds., *Readings in the Management of Innovation* (Boston: Pittman, 1982); Harvey Sapolsky, *The Polaris Development* (Cambridge, MA: Harvard University Press, 1972); and Leonard R. Sayles and Margaret K. Chandler, *Managing Large Systems: Organizations for the Future* (New York: Harper & Row, 1971).

9. See, for example, Hans Mark and Arnold Levine, *The Management of Research Institutions: A Look at Government Laboratories*, NASA SP-481 (Washington, D.C.: U.S. Government Printing Office, 1984).

10. See, for example, Richard Daft, *Organizational Theory and Design*, (St. Paul, Minn.: West Publishing, 1986).

APPENDIXES

APPENDIX A

NASA INTERVIEWS

John Aaron, interviewed by Thomas J. Lewin, April 12, 1988.

James E. Abrahamson, interviewed by Thomas J. Lewin, July 11, 1988.

Patricia Bahr, interviewed by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

Jean Bean, interviewed by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

James M. Beggs, interviewed by Thomas J. Lewin, May 25, 1988.

Marc Bensimon, interviewed by Thomas J. Lewin, July 11, 1988.

B.J. Bluth, interviewed by Thomas J. Lewin, March 31, 1988 and April 13, 1988.

Roger Breckenridge, interviewed by Thomas J. Lewin, June 14, 1988.

Ronald Browning, interviewed by Thomas J. Lewin and V.K. Narayanan, April 14, 1988.

John Butler, interviewed by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

Tom Cochrane, interviewed by Thomas J. Lewin, July 25, 1988.

Aaron Cohen, interviewed by Thomas J. Lewin, March 17, 1988.

John E. Cools, Jr., interviewed by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

Clarke Covington, interviewed by Thomas J. Lewin, March 16, 1988.

Jerry Craig, interviewed by Thomas J. Lewin and V.K. Narayanan, February 26, 1988 and March 17, 1988.

Bryant Cramer, interviewed by Thomas J. Lewin, April 13, 1988.

Philip Culbertson, interviewed by Thomas J. Lewin and V.K. Narayanan, December 9, 1987 and interviewed by V.K. Narayanan, June 8, 1988.

Charles Darwin, interviewed by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

Louis DeAngelis, interviewed by Thomas J. Lewin, July 12, 1988.

Robert Dotts, interviewed by Thomas J. Lewin and V.K. Narayanan, March 18, 1988.

Robert Easter, interviewed by Thomas J. Lewin, July 18, 1988.

Burton Edelson, interviewed by V.K. Narayanan, May 25, 1988.

Max Egert, interviewed by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

Margaret "Peggy" Finarelli, interviewed by Thomas J. Lewin, July 12, 1988.

Terence T. Finn, interviewed by Thomas J. Lewin, December 7, 1987 and interviewed by V.K. Narayanan, April 14, 1988.

Henry Flagg, interviewed by Thomas J. Lewin, March 24, 1988.

Robert Freitag, interviewed by Thomas J. Lewin and V.K. Narayanan, September 29, 1987, interviewed by Thomas J. Lewin, December 9, 1987, and August 2, 1988.

Kenneth Frost, interviewed by V.K. Narayanan, April 15, 1988.

Gerald Griffin, interviewed by Thomas J. Lewin, March 17, 1988.

Daniel Herman, interviewed by Thomas J. Lewin and V.K. Narayanan, December 11, 1987 and interviewed by V.K. Narayanan, May 23, 1988.

Noel Hinners, interviewed by Thomas J. Lewin and V.K. Narayanan, December 11, 1987 and interviewed by V.K. Narayanan, June 7, 1988.

Francis T. "Frank" Hoban, interviewed by Thomas J. Lewin, April 12, 1988.

John D. Hodge, interviewed by Thomas J. Lewin and V.K. Narayanan, September 28, 1988, interviewed by Thomas J. Lewin, May 24, 1988, and August 2, 1988.

Paul Holloway, interviewed by Thomas J. Lewin, July 14, 1988.

W. Ray Hook, interviewed by Thomas J. Lewin, June 15, 1988.

Neil Hutchinson, interviewed by Thomas J. Lewin, July 28, 1988 and August 1, 1988.

Mary Kerwin, interviewed by Thomas J. Lewin, April 12, 1988.

James Kingsbury, interviewed by Thomas J. Lewin, January 21, 1988.

Jack Lee, interviewed by V.K. Narayanan, January 21, 1988.

Allen Louviere, interviewed by Thomas J. Lewin, February 25, 1988.

William Lucas, interviewed by Thomas J. Lewin and V.K. Narayanan, January 20, 1988.

Thomas Mancuso, interviewed by Thomas J. Lewin and V.K. Narayanan, February 25, 1988.

Hans Mark, interviewed by V.K. Narayanan, June 20, 1988.

Robert Marshall, interviewed by Thomas J. Lewin and V.K. Narayanan, January 21, 1988.

James McMillon, interviewed by Thomas J. Lewin and V.K. Narayanan, January 21, 1988.

Thomas Moser, interviewed by Thomas J. Lewin, April 13, 1988.

E. Thomas Newman, interviewed by Thomas J. Lewin, December 10, 1987.

Mark Nolan, interviewed by Thomas J. Lewin, March 23, 1988.

Robert "Skip" Nunamaker, interviewed by Thomas J. Lewin, June 15, 1988.

Richard Peterson, interviewed by Thomas J. Lewin, June 23, 1988.

Brian Prichard, interviewed by Thomas J. Lewin, June 21, 1988.

William Raney, interviewed by Thomas J. Lewin and V.K. Narayanan, December 10, 1987 and interviewed by Thomas J. Lewin, May 23, 1988.

Tony Redding, interviewed by Thomas J. Lewin and V.K. Narayanan, February 25, 1988.

John Sheahan, interviewed by Thomas J. Lewin, December 8, 1987.

Carl Shelley, interviewed by V.K. Narayanan, February 26, 1988.

Kenneth Sizemore, interviewed by Thomas J. Lewin and V.K. Narayanan, April 14, 1988.

William Snead, interviewed by Thomas J. Lewin and V.K. Narayanan, January 19, 1988.

Andrew Stofan, interviewed by Thomas J. Lewin and V.K. Narayanan, May 23, 1988.

Jack Swearingen, interviewed by Thomas J. Lewin and V.K. Narayanan, January 19, 1988.

Ronald Thomas, interviewed by Thomas J. Lewin, July 18, 1988.

Richard Thorson, interviewed by V.K. Narayanan, February 26, 1988.

E. Lee Tilton, interviewed by Thomas J. Lewin, December 8, 1987.

R. Wayne Young, interviewed by Thomas J. Lewin and V.K. Narayanan, March 17, 1988.

APPENDIX B

ARCHIVAL SOURCES

Apart from interviews, congressional hearings, and the sources mentioned in the footnotes, the research on which this monograph is based rests on material in the following collections:

At NASA Headquarters

> > The Space Station Files of the NASA History Office at NASA Headquarters in Washington, D.C.

> > The Space Station History Project Historical Documents Collection, NASA History Office.

-- ***Space Station Management Council***
Space Station Management Council, 1984
Space Station Management Council, 1985
Space Station Management Council, 1986
Space Station Management Council, 1987

-- Hearth Study, 1980-1981
-- Space Station Technology Workshop, 1983
-- Management Workbook and Level A Retreat, October 15, 1986
-- NASA Management Study Group Report, December 16, 1986
-- Phase C/D Planning
-- Phase C/D RFP Process
-- Space Station Employee Development Program
-- Space Station Management Colloquium, September 22-23, 1983
-- Space Station Management Colloquium, September 22-24, 1984
-- Work Packages
-- Work Package Restructuring

-- ***Space Station Task Force***
Commercial Working Group
Concept Development Group
Director's Meetings, 1982-1983
Operations Working Group
International Cooperation (subgroup) (working group) prior to August 1, 1984
Space Station Procurement Development Group
Space Station Program Description Document
Space Station Program Review Committee
Space Station Program Planning Working Group
Studies of Space Station Needs, Attributes, and Architectural Options

At NASA Field Centers

> > Johnson Space Center History Document Collection
-- Space Station Control Board (SSCB) Directives
-- Space Station Control Board (SSCB) Minutes
-- Space Station Project Office (Level C) Correspondence
-- Space Station Project Office (Level C) Reports, Presentations, and Technical Directives
-- Space Station Project Office (Level C) Engineering and Operation Safety Panels
-- Space Station Program Management Office (Level B) Correspondence and Reports

> > Marshall Space Flight Center
- -- Space Station Project Office (Level C) Correspondence and Reports
- -- Space Station Memo/Minutes, Progress Reports, System Design, and Concept Studies
- -- Space Station Press Releases
- -- Space Station System Requirements
- -- Space Station Needs Requirements

> > Langley Research Center
- -- Space Station Project Office (Level C) Correspondence and Reports
- -- Critical Evaluation Task Force Report

> > Lewis Research Center
- -- Space Station Systems Directorate
- -- Space Station Project Office (Level C) Correspondence

> > Goddard Research Center
- -- Space Station Project Office (Level C) Correspondence
- -- Organizational Charts

> > Kennedy Space Center
- -- Space Station Project Office (Level C) Correspondence
- -- Organizational Charts

From Other Sources

> > Manfred "Dutch" von Ehrenfried, Vice President, Technical and Administrative Services Corporation, Washington, D.C.
- -- Space Station Documents, 1982-86

> > E. Lee Tilton Personal Files on the Space Station
- -- CDG Workshop Files
  Vol. I -- 10/24-27/83
  Vol. II -- 10/24-27/83
  Vol. III -- 10/24-27/83

APPENDIX C

BIOGRAPHICAL PROFILES

John Aaron joined NASA in 1964 and has served in several positions in the nation's space program. He served as Special Assistant to the Director of Johnson Space Center. In February 1986 he became Acting Manager of the Space Station Program Office and continued as Deputy Manager of that office. In July 1987 he was named Acting Assistant Administrator for Exploration at NASA Headquarters.

General James A. Abrahamson was named Associate Administrator for Space Transportation Systems in November 1981, on assignment from the Air Force. He succeeded John Yardley. In 1979 he was chosen by NASA for a special team charged with assessing the management of the Space Transportation System. He served on the Staff of the National Aeronautics and Space Council in the Executive Office of the President.

Lew Allen was appointed Director of the Jet Propulsion Laboratory in October 1982. He previously served as Air Force Chief of Staff and a member of the Joint Chiefs of Staff.

Peter M. Banks, Director of Stanford University's Space Telecommunications and Radio Science Laboratory, was selected by NASA to head a 16-man task force of U.S. space scientists to assist NASA in defining the scientific uses and requirements for the planned manned space station.

James M. Beggs joined NASA first in 1968 when he became Associate Administrator in the Office of Advanced Research and Technology. From 1969 to 1973 he served as Undersecretary in the Department of Transportation. He went to Summa Corporation as Managing Director of Operations, and joined General Dynamics in 1974. Before joining NASA again he worked for Westinghouse Electric Corporation for thirteen years. He became Administrator of NASA on July 10, 1981, took a leave of absence starting December 4, 1985, following his indictment. He resigned February 25, 1986 from the space agency.

David C. Black was Chief Scientist of the Space Research Directorate at the Ames Research Center, and served as Chief Scientist for the Space Station from the time the position was created in 1984, through the reorganization, until June 1987.

Ronald Browning was Project Officer (Level C) at Goddard Space Flight Center for the Space Station Program.

Aaron Cohen came to NASA in 1962 and joined the Apollo Spacecraft Program Office at Johnson Space Center. From 1970 to 1972 he served as Manager for the Command and Service Module in the Apollo Program. From 1972 to 1982 he was Manager of the Space Shuttle Orbiter Project, and from 1982 to 1983 he was Director of the Engineering and Development Directorate at Johnson. In October 1986 he replaced Jesse Moore as Director at Johnson.

Clarke Covington came to Johnson Space Center in 1962. He held positions of increasing responsibility within Johnson prior to his selection to be Manager of the Engineering and Operations Office for the Space Station project. He was subsequently chosen to be the Manager of the Space Station Project Office at Johnson.

Jerry W. Craig joined Johnson Space Center in 1969 and by 1973 had become the Chief of the Systems Integration Branch of the Apollo Spacecraft Program Office. From 1973 to 1984 he held positions of increasing responsibility within Johnson. In 1983 he moved to NASA Headquarters and subsequently became the Chairman of the Program Planning Working Group of the Space Station Task Force. In 1984 he returned to Johnson and became Manager of the Project Engineering Office in the Space Station Project Office. In 1987 he became Deputy Manager of the SSPO, and is presently Manager of the Crew Emergency Return Vehicle Office.

Philip E. Culbertson headed the Space Station Program when it first started as its Manager, and later as the first Associate Administrator. He served as a high level member of the Space Shuttle design and development team. After working at NASA for 22 years, he retired in January 1987 to become President of the Lew Evans Foundation, which was established in 1983 in tribute to the former President and Board Chairman of the Grumman Corporation who died in 1972. His position in NASA at the time he retired was Associate Administrator for Policy and Planning.

Burton I. Edelson came to NASA as Associate Administrator for Space Science and Applications in February 1982. Before coming to NASA, he spent fourteen years with the Communications Satellite Corp. (COMSAT), in Washington, D.C., rising to the position of Senior Vice President. He left NASA in 1987.

Maxime A. Faget joined the science staff of Langley Research Center in 1946. He was assigned to the Applied Materials Physics Division and was named Head of the Performance Aerodynamics Branch of that division. He served as Director of Engineering and Development at Johnson Space Center and was replaced by Aaron Cohen.

Margaret "Peggy" Finarelli served as chief of the International Planning and Programs Office in the International Affairs Division at NASA Headquarters. In September 1986 she became Director of the Policy Division at Headquarters. In December 1988 she was appointed to the position of Deputy Associate Administrator for External Relations.

Terence T. Finn, a policy analyst, was reassigned in September 1981 as Deputy Director of Government and Industry Affairs. In 1982 he joined the Space Station Task Force, which studied the pros and cons of the space station program.

James C. Fletcher became Administrator of NASA on April 27, 1971 and held that position until May 1, 1977. He left NASA to become the Whiteford Professor of Technology and Energy Resources at the University of Pittsburgh. In March 1986 Dr. Fletcher was nominated to be Administrator, succeeding James Beggs. He was the fourth and seventh administrator of NASA.

Robert F. Freitag came to NASA in 1963, and served 23 years, beginning in the Office of Manned Space Flight. He first served as Director of Launch Vehicles and Propulsion in the OMSF from March to November 1963. He then became the Director of Field Center Development for OMSF from November 1963 to January 1971. He completed his work with OMSF as Deputy Director of the Advanced Program Office. In 1981 he focused his efforts on the space station initiative and became Deputy Director of the Space Station Task Force. He completed his career with NASA as the Director of the Policy and Plans Office of the Office of Space Station at Headquarters. He retired from NASA in early 1986.

Robert A. Frosch was appointed NASA Administrator from June 1977 to his retirement in January 1981, at 52 years of age. Prior to his appointment as Administrator, he was Associate Director for Applied Oceanography at Woods Hole Oceanographic Institute.

Ernst D. Geissler joined NASA in 1960 upon the formation of Marshall Space Flight Center although he had been part of the Marshall "team" since January 1940. In 1960 he was the Director of the Aeroballistics Division at Marshall. During the 1960s he worked on the booster for the Saturn rocket series. For the Space Station Program he was involved in meetings in anticipation of Kennedy Space Center's involvement when the station became operational.

Robert C. Goetz joined NASA's Langley Research Center in July 1959. He was a U.S. Air Force officer from late 1959 to 1962, assigned to Langley. In 1979 he was assigned to NASA Headquarters to head structures and dynamics research. He returned to Langley in 1980 as Special Assistant to the Chief of the Structures and Dynamics Division. He was appointed Director for Structures in June 1980. In July 1983 he became Deputy Director at Johnson Space Center, and was named Acting Director of Johnson upon Gerald Griffin's departure in January 1986.

William R. Graham became Deputy Administrator of NASA on November 15, 1985, replacing Hans Mark. He served in that capacity until October 1986, when he became Director of the Office of Science and Technology Policy. He also served as Science Advisor to the President. Prior to his appointment at NASA he was an executive of R&D Associates, Marina Del Rey, California, which he co-founded in 1971. In 1980, Graham served as an advisor to Ronald Reagan and was a member of the President-Elect's transition team. He was also Chairman of the General Advisory Committee on Arms Control and Disarmament, having been nominated by the President and confirmed by the Senate in 1982.

Gerald D. Griffin joined NASA in 1964. He served for more than 20 years in a number of key positions at three NASA centers and in Washington, D.C. In August 1982 he became the Director at Johnson Space Center and held that position until his departure in January 1986 to become President of the Houston Chamber of Commerce.

Donald P. Hearth held several senior management positions at Headquarters and was Deputy Director of Goddard Space Flight Center before being named Director of Langley Research Center in 1975. He left Langley in February 1985 to become Director of Space Science and Technology at the University of Colorado in Boulder.

Daniel H. Herman served as Director of the Engineering Division, Office of Space Station and was on the Space Station Task Force. He was named Senior Engineer in December of 1986, a new staff position created under the reorganization of the Space Station Program.

Noel W. Hinners first joined NASA in 1972 as Deputy Director of Lunar Programs in the Office of Space Science. From 1974 to 1979 he was Associate Administrator for Space Science. He was Director of the Smithsonian Institution's National Air and Space Museum prior to being appointed Director of Goddard Space Flight Center in 1982. In October 1988 he was appointed Associate Deputy Administrator, continuing in his function as chief scientist and supervising the institutional management in NASA.

Francis T. "Frank" Hoban joined NASA in 1963 at Langley Research Center. He left Langley to serve on the staff of the NASA Administrator in 1970. He served as the Executive Assistant to Dr. Wernher von Braun and later Dr. George Low, the former Deputy Administrator of NASA. He served on the Space Station Task Force which was established on May 20, 1982. He subsequently became the Acting Director of the Program Support Office for the Office of Space Station.

John D. Hodge was born and educated in England, joining NASA in 1959 after a distinguished career in England and Canada. He was named Chief of Flight Control. He left NASA in 1970 for the Department of Transportation, but returned in 1982 to become Director of the Space Station Task Force. He was appointed Deputy Director of the Interim Space Station Program Office in April 1984 when the Task Force completed its work. He then became Deputy Associate Administrator for the Space Station, became Acting Associate Administrator for Space Station in December 1985, and Associate Administrator for Operations in August 1986.

Paul F. Holloway joined the staff at Langley Research Center in June 1960. He became Head of the Applied Physics Division of the Systems Analysis Section in 1969 and Head of the Space Systems Division of the Aerospace Operations Analysis Section in 1970. He served as Director for Space at Langley from 1975 until he was named Deputy Director of Langley in February 1985.

W. Ray Hook came to Langley Research Center in 1955, served in the Air Force from November 1955 to April 1958, and returned to Langley when his tour was done. He served at NASA Headquarters as Acting Director for Space Shuttle Technology Payloads. He was also head of Langley's Shuttle Experiments Office. He served as Manager of Langley's Space Station Office, and was then named the Director for Space at Langley, replacing Robert "Skip" Nunamaker.

Neil Hutchinson served as Space Station Program Manager at Johnson Space Center from April 1984 to February 1986. He was named Program Manager shortly after NASA formed the Program Office and assigned overall responsibility to Johnson. He remained at Johnson as Assistant to the Director of Space Operations.

James E. Kingsbury joined NASA in July 1960 when the Army Ballistic Missile Agency became the nucleus for the establishment of Marshall Space Flight Center. He has served in various positions at Marshall during that time. In June 1974 he became Associate Director for Engineering in the Science and Engineering Directorate at Marshall, and in April 1975 became the Director. He retired from that position on November 30, 1986.

Thomas R. Kloves joined Johnson Space Center in November 1963 and served in various technical and managerial positions in the Center. In September 1984 he was appointed Manager of the Program Management Office for the Space Station.

Christopher C. Kraft, Jr. joined the staff of the National Advisory Committee for Aeronautics (forerunner to NASA) in 1945 and in 1958 became an original member of NASA's Space Task Group. He served as Flight Director for Project Mercury form 1960 to 1963. He was named Deputy Director of Johnson Space Center in 1969 and Director in 1972. He resigned from the Directorship on August 7, 1982.

Robert V. Lottman joined NASA as an attorney in the Office of Patent Counsel at Goddard Space Flight Center in 1966. From 1967 to 1972 he served on the staff of the Assistant General Counsel for Patent Matters at Headquarters. In 1972 he joined the Legislative Division of the Office of Legislative Affairs. He was named Director of the Congressional Liaison Division of the Office of Legislative Affairs in March 1979.

Allen J. Louviere joined Johnson Space Center in April 1963 and served in various technical and managerial positions in what became the Engineering Directorate. In August 1981 he was designated Manager of the interim Space Operations Center Program Office at Johnson. In July 1983 he was assigned to be Assistant for Program Development to the Director of Research and Engineering. In September 1984 he was appointed Manager of the Systems Engineering and Integration Office for the Space Station Program.

William R. Lucas became Director of Marshall Space Flight Center in June 1974, after having served three years as Deputy Director. He was with Marshall and its predecessor organizations for more than 30 years in various scientific and program management positions. He retired as Director of Marshall on July 3, 1986.

Hans M. Mark served as director of Ames Research Center in California from 1969 until 1977. Dr. Mark had left NASA in 1977 to serve in the Department of the Air Force, first as Undersecretary (1977-1979) and then as Secretary (1979-1981). He returned as Deputy Administrator in July 1981 under James Beggs. He left NASA in September 1984, to become Chancellor of the University of Texas System. He co-authored a book with Arnold Levine, published in 1984, entitled *The Management of Research Institutions: A Look at Government Laboratories*. He was born in Germany June 17, 1929, and became a citizen of the United States in 1945.

Jesse W. Moore came to NASA Headquarters in 1978 as Deputy Director of the Solar Terrestrial Division in the Office of Space Science. He also served as Director of the Space Flight and Earth and Planetary Exploration Divisions. He was appointed Deputy Associate Administrator for Space Flight in 1983 and served as Acting Associate Administrator for Space Flight from April 1984 until he was appointed Associate Administrator on August 1, 1984. He was named Director of Johnson Space Center on January 23, 1986 and was reassigned as Special Assistant to the General Manager at NASA Headquarters on October 12, 1986.

Thomas L. Moser came to Johnson Space Center in 1963. From 1966 to 1971 he was the Structural Subsystems Manager for the Apollo command module and subsequently became Project Manager for the Shuttle Structures and Mechanics Division. In 1972 Moser was named Head of Structural Design and Manager for Orbiter Structural and Thermal Projection Systems. He became Technical Assistant to the Director of Johnson in 1981 and was named Deputy manager of the Orbiter Project Office in 1982. He assumed the position of Director of Engineering in 1983. He came to NASA Headquarters in February 1983, when he was appointed Deputy Associate Administrator for Space Flight. He was serving as Director of the Space Station Freedom Program when he was selected as Deputy Associate Administrator for the Space Station in December 1988.

James B. Odom began his government service in 1956 at the Army Ballistic Missile Agency. When Marshall Space Flight Center was established in 1960, he transferred there. In 1972 he was named Manager of the External Tank Project in the Shuttle Projects Office. In 1982 he became Deputy Manager for Production and Logistics in the Shuttle Projects Office. In April 1983 he was appointed Manager of the Space Telescope Office. In November 1986 he was named to succeed James Kingsbury as Director of the Science and Engineering Directorate at Marshall. He subsequently became Head of the Space Station Office at NASA Headquarters.

Lt. General Samuel C. Phillips directed the Apollo Program from 1964 to 1969. He retired from the Air Force in September 1975. He headed the post-Challenger studies that led to a reorganization of NASA.

Robert O. Piland returned to Langley Research Center in late 1988 to assume the duties of Chief of the Space System Division. He was formerly National Aero-Space Plane Director for NASA in the NASP Program Management Office at Headquarters.

Luther Powell joined Marshall Space Flight Center in 1960. He worked on the Saturn I and IB projects, Skylab, and Spacelab. He served as Manager of the Space Station Projects Office at Marshall from 1982 until his retirement from NASA on August 5, 1988.

William P. Raney joined NASA in 1978 as the Chief Engineer for the Office of Space and Terrestrial Applications. On December 31, 1978, he was named Assistant Associate Administrator of the same office. He had served as Director of the Utilization and Performance Requirements Division, and became Special Assistant to the Associate Administrator after the reorganization of the Space Station Program in 1986.

William Eugene Rice joined Johnson Space Center in October 1962 and served in various technical and managerial positions. In April 1983 he became Assistant to the Director of Research and Engineering. In September 1984 he became Manager of the International and External Affairs Office and Director of the International Programs Group Space Station Program Office (JSC and NASA Headquarters).

Carl B. Shelley joined Johnson Space Flight Center in November 1964. At the beginning of the space station initiative he was Deputy Chief of the Training Division, and became Deputy Director of the Mission Operations Directorate in 1983. In September 1984 he was selected to be Manager of the Space Station Customer Integration Office, which he held for three years. In 1987 he became Manager of the Operations Integration office of the Mission Operations Directorate, and in 1988 he became Deputy Manager of the Space Station Projects Office at Johnson.

Richard G. Smith came to NASA in 1960 when the Development Operations Division of the Army Ballistic Missile Agency became the Marshall Space Flight Center. He served in positions of increasing responsibility at Marshall and was appointed Deputy Manager and later Manager of the Saturn Rocket Program. In January 1974 Smith became Director of Science and Engineering and was appointed Deputy Director of Marshall later that year. In August 1978 he accepted a one-year assignment as Deputy Associate Administrator for Space Transportation Systems at NASA Headquarters. He also served as Director of the Skylab Task Force. He retired as Director of Kennedy Space Center on July 31, 1986, to become President and Chief Executive Officer of General Space Corp.

Andrew J. Stofan began his professional career at Lewis Research Center in 1958 as a research engineer. From 1966 to 1978, Stofan managed a variety of technical projects at Lewis. In 1978, Stofan was appointed Deputy Associate Administrator for the Office of Space Science and Applications at NASA Headquarters, and held the title of Acting Associate Administrator for that office from 1980 until 1982, when he was appointed director of Lewis. He became Associate Administrator for the Space Station on June 30, 1986 and directed the Space Station Program through a difficult period marked by significant progress. He retired from NASA April 1, 1988, at the age of 53.

Ron Thomas joined Lewis Research Center in 1961. He worked on production and generation of electricity from solar sources at Lewis and managed the Wind Energy Program for the Department of Energy (also at Lewis). He was the Project Officer (Level C) at Lewis Research Center for the Space Station Program.

Richard A. Thorson joined Johnson Space Center in June 1966 and served in various technical and managerial positions in what became the Mission Operations Directorate. In September 1984 he was appointed Manager of the Space Station Operations Office.

E. Lee Tilton, III, joined NASA in 1964 and held a number of positions within the agency, including Deputy Director of the Earth Resources Laboratory from 1974 to 1981. He held various positions at NASA Headquarters including Deputy Director of Advanced Program Development, Acting Assistant Associate Administrator for the Office of Space Flight, and Acting Director of the Commercially Developed Space Facility. He was named Director of the Science and Technology Laboratory at the John C. Stennis Space Center in September 1988.

James E. Webb served as NASA Administrator from February 14, 1961, to October 7, 1968. He was the second Administrator in the history of NASA. He returned to the private sector as a lawyer and consultant.

John F. Yardley joined NASA in 1974 as Associate Administrator for Manned Space Flight. He became Associate Administrator for Space Flight in 1976, and was Associate Administrator for Space Transportation Systems from 1978 until 1981. Prior to joining NASA he was Vice President and General Manager of the Eastern Division, McDonnell Douglas Astronautics Co. in St. Louis. He returned to McDonnell Douglas in May 1981 to become President of the company.